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**JOURNAL
OF
SOUTH AFRICAN
BOTANY**

VOLUME 44

1978

2807/1

*Published under the authority
of the*

**Trustees
of the
National Botanic Gardens
of
South Africa,
Kirstenbosch,
Newlands, C.P.**

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Publication dates:

44 (1): 1- 96 [6th January, 1978]
44 (2): 97-202 [18th April, 1978]
44 (3): 203-315 [25th July, 1978]
44 (4): 317-421 [30th October, 1978]

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THIS VOLUME IS DEDICATED TO

JOHN PATRICK MICKLETHWAIT BRENAN (1917—)

M.A., B.Sc., F.L.S., F.I. Biol.

(Director of the Royal Botanic Gardens, Kew)

a specialist and authority on African plants, especially the families Commelinaceae, Steruliaceae, Chenopodiaceae and Leguminosae; he has made extensive observations and collections throughout Tropical and Southern Africa which form the bases for numerous publications to his credit, these include a descriptive check list of the Woody Plants of Tanganyika (1949) published in collaboration with P. J. Greenway as well as valuable contributions to the Floras of Tropical East Africa, West Tropical Africa and Flora Zambesiaca; he has been associated with a number of important scientific societies, having been Botanical Secretary of the Linnean Society of London from 1965–72, President of the Association of Tropical Biology in 1970–71 and is also a member of the Library and Scientific Committees of the Royal Horticultural Society; throughout his botanical career he has kept a close liaison with Kirstenbosch and other major South African Botanical Institutes, to which he has given freely of his advice concerning matters of policy and management.

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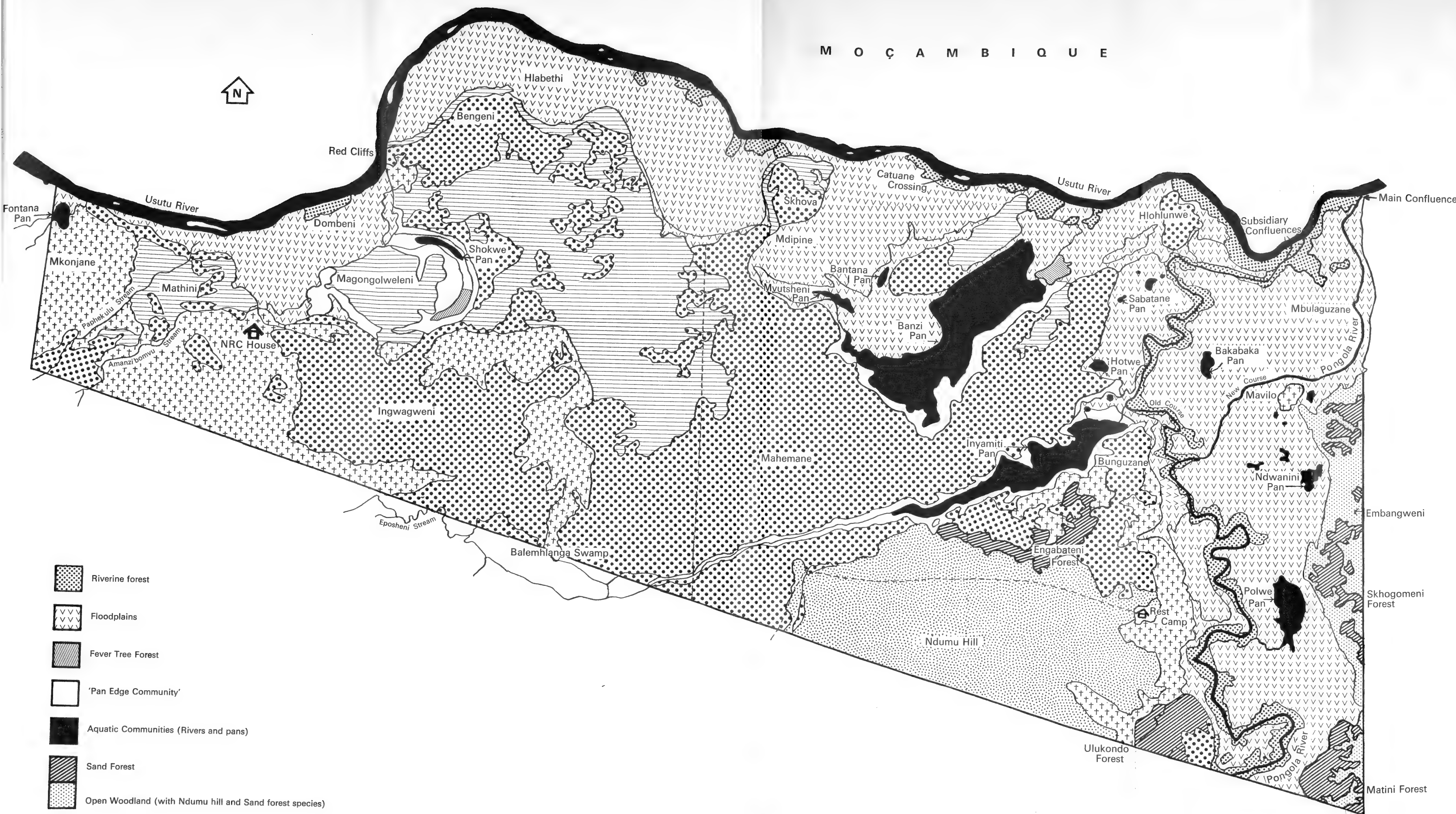


FIGURE 2

Map of the vegetation of Ndumu Game Reserve

Simplified from the 'Map of the vegetation formations of Ndumu Game Reserve' by De Moor et al (which was drawn directly from the 1964 aerial photographs)

E.S.P. 1977

SCALE 1 : 36,000 APPROXIMATELY

A CHECKLIST OF THE PLANTS OF NDUMU GAME RESERVE, NORTH-EASTERN ZULULAND

E. S. POOLEY

(*St. Lucia Estuary, Natal*)

ABSTRACT

An annotated checklist of the plants of Ndumu Game Reserve, northern Zululand is given together with a brief floristic analysis and a description of the vegetation types of the area. A map is included.

UITTREKSEL

'N LYS VAN DIE PLANTE IN DIE NDUMU WILDRESERVAAT IN NOORD-OOS
ZOELOELAND

'n Lys van plante met aantekeninge in die Ndumu Wildreservaat, Noord Zoeloeland, word aangebied met 'n kort floristiese ontleding en 'n beskrywing van die plantegroei tipes van die area. 'n Kaart word ingesluit.

INTRODUCTION

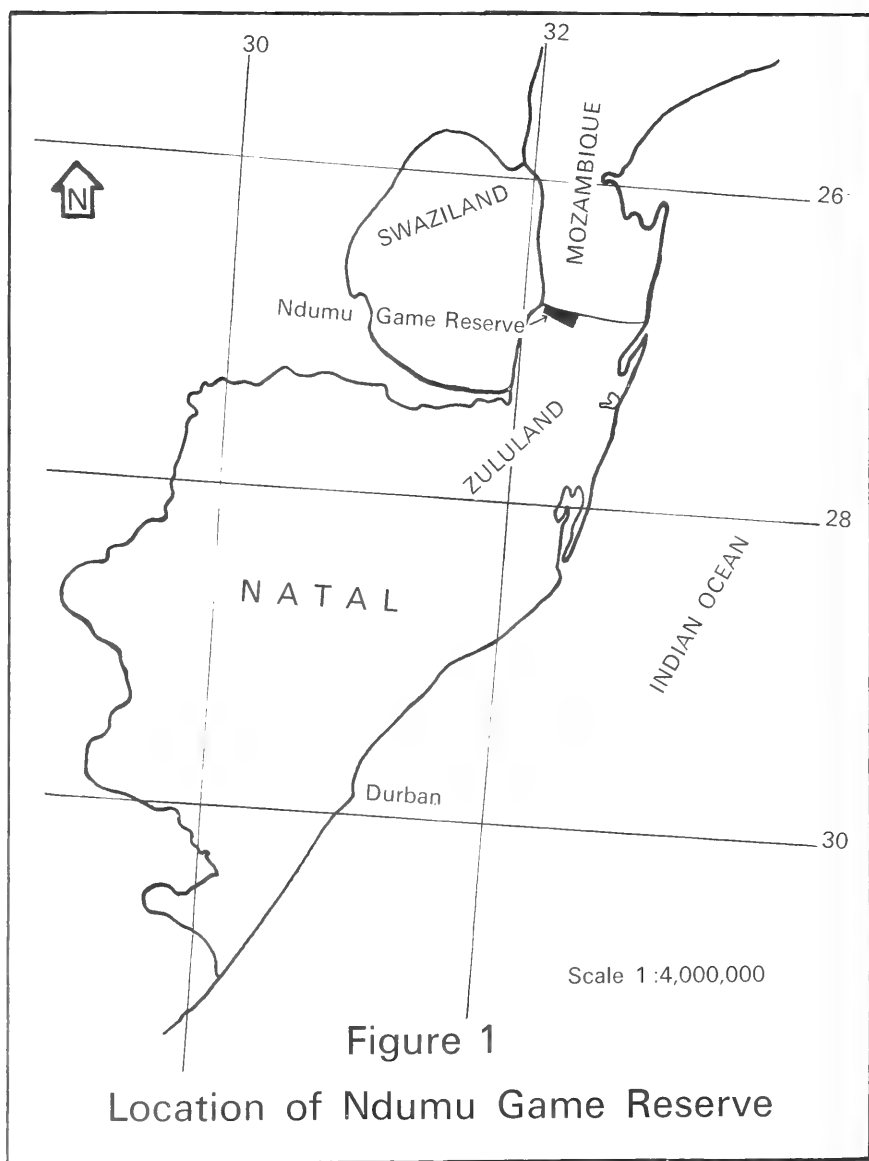
The material for the checklist was collected during the period 1967 to 1974. The specimens have been routinely named in the Department of Botany, University of Natal, Pietermaritzburg and are housed in that herbarium, with many duplicates in the Natal Parks Board Herbarium, Hluhluwe Game Reserve. Other collections cited are also housed in these two herbaria, namely those of E. J. Moll, T. B. Oatley, J. M. Ross, K. L. Tinley, C. J. Ward and some others.

The plants in the checklist are limited to those of the game reserve in spite of the fact that some most interesting material has also been collected just to the west on the Lebombo foothills, and from the Sand Forest areas just to the east.

GENERAL DESCRIPTION OF GAME RESERVE

Ndumu Game Reserve is 10 100 ha in extent and is situated in north-eastern Zululand (Tongaland) on the border between South Africa and Mozambique (Fig. 1). It lies at the southernmost extension of the Mozambique plain at approximately latitude S 26° 53' longitude E 32° 15', about 70 km from the sea.

The Usutu river, known as the Rio Maputo in Mozambique, serves as part of the international border as well as the game reserve boundary on the north. The game reserve is fenced on the south, east and west. The Pongola river flows through the reserve from the south boundary to its new confluence with the Usutu



in the north. The old course of the Pongola serves as a flood water feeder channel to Inyamiti, iHotwe and Sabatane pans, either directly from the Pongola or as feed-back from the Usutu river, depending on water levels in the two rivers. There are several semi-permanent pans; Fontana, Shokwe, Bantana, Mvutsheni and Banzi on the Usutu; and isiHilibindini, Mpumpununa, iPolwe, Inyamiti, iHotwe, Sabatane, Ndwani and Bakabaka on the Pongola, which are filled by these perennial rivers. The extensive floodplains form approximately a third of the reserve.

Its highest point is Ndumu Hill which rises from the Pongola floodplain (25 m above sea level) to a height of 160 m above sea level. The foothills of the Lebombo rise in the extreme west of the reserve. There are flats in between these two elevated areas, with extensive areas of tall thicket with scattered trees, low thicket with few trees (termed "scrub" in checklist), woodland and savanna.

The game reserve was proclaimed in 1924. Until 1959, about 1 000 Africans and their goats and cattle lived there. Crops were cultivated mainly on the floodplains. During 1959, all stock were removed and subsequent recuperation of the vegetation was phenomenal (Tinley, 1964). The last Africans were moved out of the reserve in 1966, but there is still considerable evidence of old kraal sites and, especially on the Usutu Floodplain, of disturbed vegetation in old fields.

Arson has always been a factor in the life of the game reserve. Fires are put in by poachers with regularity, particularly in the west but also, on occasions, on Ndumu Hill.

The climate is sub-tropical, with a summer rainy season lasting from October to April, although onset, duration and amount are very variable. In winter, dense morning mists occur as a fairly regular feature. Mean monthly rainfall and temperature data are contained in Table 1 (from De Moor *et al.*, in press).

TABLE 1.
Average monthly rainfall and temperature data from Ndumu Game Reserve

Month	Rainfall (mm) (1956-1971)	Temperature (° C)
		(Max. \pm Min. 1968-1971) 2
January	44,4	27,1
February	79,7	26,8
March	61,2	25,8
April	43,4	23,8
May	17,2	20,4
June	14,7	18,1
July	10,7	19,1
August	14,4	20,6
September	23,4	22,2
October	74,4	24,3
November	75,3	24,3
December	75,9	26,6

TOTAL AVERAGE ANNUAL RAINFALL: 534,7 mm

VEGETATION

A vegetation and soil survey was conducted in 1971 and 1972 by De Moor and his collaborators, and twenty-nine vegetation formations were described according to physiognomic characteristics (following Fosberg, 1967). A vegetation and soil map is included in that work. For the purposes of this paper the game reserve will be described following the main eight formations delimited in the De Moor survey, but in less detail and drawing attention to areas of particular botanical interest. A map is included showing the Zulu names for the various parts of the game reserve and showing the main vegetation formations (Fig. 2).

Riverine Forest

This occurs as a broken strip of forest along the banks of the Usutu and Pongola rivers, typically found on levées formed by floodwaters. The main tree species are *Ficus sycamorus*, *Rauvolfia caffra*, *Trichilia emetica*, *Syzygium guineense*, *Adina microcephala*, *Ekebergia capensis*, *Sapium ellipticum* and *Phyllanthus flacourtioides*, which form a discontinuous canopy. The sub-canopy can include *Antidesma venosum*, *Phoenix reclinata*, *Kraussia floribunda*, *Tabernaemontana elegans*, *Oncoba spinosa* and *Gardenia cornuta*. Shrubs and climbers include *Allophylus decipiens*, *Grewia caffra*, *Ficus capraefolia*, *Acacia schweinfurthii*, *Monanthes caffra*, *Pisonia aculeata*, *Capparis tomentosa*, *Ipomoea digitata*, and *Gymnema sylvestre*. Herbs and grasses found are *Justicia glabra*, *Achyranthes aspera*, *Setaria chevalieri* and *Oplismenus hirtellus*.

The area of forest described in De Moor *et al.*, with a continuous canopy of 30 m, is the only such undisturbed area of forest of any size—and is now claimed by Mozambique as it is in the confluence area of the Usutu and Pongola rivers and is cut off by two of the old courses of the Pongola rivers.

The new course of the Pongola river has no Riverine Forest, but forest species from the old course are spreading steadily down the new course.

Usutu Floodplain

Much of this floodplain is not inundated regularly, only at times of exceptionally high flood levels. The composition of grass and sedge species differs greatly from the Pongola Floodplain and is much more diverse. There are many channels which are flooded most seasons; a noteworthy one being the Mtkeni which links the Usutu river to the Mdipini pools, Bantana, Mvutsheni and Banzi pans. These channels, being regularly flooded, support mostly wetland species which include: *Phragmites* spp., *Cyperus* spp., *Pennisetum glaucocladum*, *Sorghum verticilliflorum*, *Hemarthria altissima* and *Typha latifolia*. Patches of Riverine Forest are found across the floodplain, and single large trees of the species *Acacia albida*, *A. tortilis*, *Sclerocarya caffra*, *Bolusanthus speciosus*, *Kigelia africana*, *Lonchocarpus capassa*, *Ficus sycamorus* and *Trichilia emetica* occur. The common grasses on the sandy alluvium are *Cymbopogon validus*, *Hyperthelia dissoluta*,

Themeda triandra, *Aristida congesta* subsp. *congesta* and *barbicollis*, *Sporobolus fimbriatus*, *Eragrostis superba*, *Trichoneura monachne* and *Cynodon dactylon*, with shrubby thickets of *Pluchea dioscoridis*, *Vernonia colorata*, *Lippia javanica* and *Securinega virosa*.

Pongola Floodplain

This floodplain before it was affected by Jozini dam was either inundated for several weeks each summer or sometimes not at all. However, once the dam started controlling the flow of the river the floodplain was inundated to its highest levels at unseasonal times and for extended periods of time. This has had a great effect on the composition of grasses and sedges, which are changing steadily. On wet mud (and over water) *Echinochloa pyramidalis* (prostrate form), *Hemarthria altissima* and *Cyperus fastigiatus* predominate with the herb *Grangea maderaspatensis*. The grasses along the edge of the floodplain and on raised levées are mostly *Eriochloa meyerianum* (= *Panicum meyerianum*), *Panicum coloratum*, *Chloris gayana*, *Sorghum verticilliflorum*, *Paspalum commersonii*, *Eriochloa stapfiana*, *Urochloa mossambicensis*, *Digitaria* spp., *Echinochloa pyramidalis* (erect form). This area is heavily utilised by hippo, and in winter, when grazing elsewhere is low, rhino, nyala, impala and reedbuck can be found in large numbers. *Sesbania sesban*, *Phragmites* spp., and *Ficus capraefolia* form a discontinuous transitional area between forest and grasses. East of the Pongola near Mavilo, spurwing geese can be found in great numbers in the shelter of the reedbeds during the birds' moulting season.

An "island", actually the little hill at the tip of a low peninsula connected to the land east of the Pongola river, is found in the middle of an extensive area of the Pongola floodplain. Known as Mavilo, its vegetation is, to some extent, unique. The hill runs N/S with stunted Sand Forest on the east slope while the rest is rocky and resembles *Acacia nigrescens* Thicket on boulder beds, with "pan-edge" species around the base.

Fever Tree Forest

Pure stands of Fever trees, *Acacia xanthophloea*, occur at the south western end of Shokwe (a fairly newly formed forest) and at the eastern end of Banzi pan. This is tall, pure *A. xanthophloea*, with a uniform crown height of 20 m, with occasional thickets of *Gardenia cornuta*, *Azima tetracantha*, *Acacia schweinfurthii* and *Maytenus heterophylla*. *Chloris gayana* is the dominant and almost the only understorey species. The fever trees around Inyamiti form a narrow band and are thus considered part of the "pan-edge" community.

"Pan-edge" Communities

These communities are very variable. *Acacia robusta*, *A. xanthophloea*, *Ficus sycamorus* (missing from Inyamiti, perhaps because of the brackish water)

Sideroxylon inerme, *Spirostachys africana* and *Schotia brachypetala* are amongst the species found growing as thicket, forest or scattered trees. *Phragmites* spp. and *Cyperus* spp. can form an intermediate strip between water, mudflats and trees (sometimes very extensive.) A separate and quite different area of floodplain or "pan-edge" is found at both ends of Inyamiti. These are the flats that are exposed all winter (under normal flood conditions) and flooded for some time each summer. When the water drops it exposes lawns of *Cynodon dactylon* with some *Sporobolus virginicus* and *Digitaria swazica*. This area is well utilised by hippo, rhino, antelope and geese. Inyamiti is brack and produces a salty crust at the western end. *Salicornia pachystachya* and *Arthrocnemum natalense* var. *natalense* are an unusual feature of the area.

There have been consecutive, abnormally high rainy seasons which have caused changes to the margins of some of the pans. Inyamiti and iHotwe pans on the Pongola floodplain have been affected by high flood levels. The *Phragmites* spp. and *Nymphaea* spp. of Skehla pan (on north bank of Inyamiti) have almost disappeared, and *Acacia xanthophloea* is dying off in large numbers, and only very few young plants occur along the shoreline. Shokwe has been inundated much longer than usual (starting in December, 1971 and particularly since 1974) and the *A. xanthophloea* and the fairly newly established Riverine Forest on the west bank are suffering considerable numbers of die-offs.

There used to be a small stream flowing from Banzi pan, through the *A. xanthophloea* forest into a swamp and eventually draining into the Pongola river. High floodwaters from Banzi have washed beds of *Typha latifolia*, *Phragmites* spp. and the gently sloping grassy banks away creating a donga and transforming the area.

Inyamiti pan, famous for the wealth of bird and animal life it supports, is fed by a stream which drains off the Ndumu farm lands. It is not known how the insecticides which also drain off, have and will affect the plant and animal life in and around the pan.

Aquatic communities

The semi-permanent pans of the game reserve and the Pongola river, especially the old course, hold a wealth of submerged and emergent aquatic plant life. Floating rafts of a mixture of *Ricciocarpos natans*, *Azolla pinnata*, *Spirodela* spp. *Wolffia arrhiza* and *Pistia stratiotes* are found on the Pongola river and floodplain. The pans hold changing communities of *Potamogeton* spp., *Ruppia maritima*, *Ceratophyllum demersum*, *Utricularia inflexa* var. *inflexa* and others, which provide a plentiful supply of food for waterfowl and fish.

In Banzi pan, the once nearly continuous floating raft of vegetation comprising a mixture of *Leersia hexandra*, *Pycreus mundtii*, *Oxycaryum cubense* (= *Scirpus cubensis*), *Echinochloa pyramidalis* (prostrate form), *Trapa natans*, *Nymphaea* spp., *Pistia stratiotes* and *Ludwigia octovalvis* subsp. *octovalvis* has apparently

been completely disrupted (1976) and, this being the case, one wonders what has become of the submerged aquatics. High floodwaters are considered the cause of the disruption.

The small seasonal pools and water courses of the Mahemane and the west have some most interesting aquatics, many only found here, such as *Ottelia exserta*, *Lagarosiphon verticilliflorum*, *Aponogeton junceus*, *Burnata enneandra*, *Lymnophytum obtusifolium*, *Nymphoides* sp. c.f. *rautenanii*, *Utricularia inflexa* var. *stellaris*, *Scirpus articulatus* and *Eleocharis fistulosa*.

Sand Forest

There are two areas of Sand Forest on Ndumu Hill; Ulukondo and Engabateni, both of which have suffered at times from over-utilisation by game, particularly nyala and bushpigs, and disturbance by man. Engabateni has been disrupted to a greater extent than Ulukondo. East of the Pongola Floodplain there are other patches of Sand Forest, some fairly extensive, which have a much higher canopy but are otherwise composed of the same species. The open areas between these forest patches have a mixture of Ndumu Hill broadleaf species and Sand Forest species, with grass and occasional thorny thickets on previously disturbed ground.

Newtonia hildebrandtii grows to 12 m and more, emergent above the 6 to 9 m canopy of the forest which has *Cleistanthus schlechteri* and *Pteleopsis myrtifolia* as the dominants, with *Brachylaena huillensis*, *Albizia petersiana* subsp. *evansii*, *A. forbesii*, *Croton gratissimus*, *Wrightia natalensis*, *Hymenocardia ulmoides*, *Combretum* spp., *Strychnos decussata*, *Haplocoelum gallense* and *Manilkara discolor* as the taller tree species. Small trees include *Monodora junodii*, *Canthium* spp., *Boscia foetida* subsp. *longipedicellata*, *Toddaliopsis bremekampii*, *Gardenia amoena*, *Drypetes arguta*, *Cola microcarpa*, *Erythroxylon emarginatum*, *Craibea zimmermannii*, *Suregada zanzibarica*, *Salacia leptoclada* and *Sapium integerrimum*. The shrub layer includes *Tricalysia* spp., *Carissa tetramera*, *Cussonia arenicola*, *Dalbergia* sp. c.f. *D. nitidula*, *Croton steenkampiana*, *C. pseudopulchellus* and *Schlerochiton coeruleus*. Climbers include *Quisqualis parviflora*, *Dioscorea cotinifolia*, *Strophanthus* spp., *Asparagus* spp., *Secamone* spp., and *Ipomoea cairica*. The ground layer is sparse with *Strylchiton natalense*, *Colotrype natalensis*, *Sansevieria* spp., and *Panicum deustum*.

Acacia tortilis Woodland

There are a number of pure stands of *Acacia tortilis*. Some of those on the Mahemane flats area have a canopy of 6 m. Those on the edge of the Usutu Floodplain have a canopy of 9 m and have many climbers and some thickets, with good grass cover as an understorey. These plants include the climbers *Cocculus hirsutus*, *Capparis tomentosa*, *Diospyros villosa*, *Sarcostemma viminalis*, *Tylophora lycioides* and *Senecio pleistocephalus*, small trees and shrubs such as *Gardenia cornuta* and *Azima tetracantha*, and a few tall trees such as *Trichilia*

emetica, *Balanites maughamii* and *Kigelia africana*, with the grass *Panicum maximum* the dominant herbaceous understorey.

There are large disturbed areas in the west where *A. tortilis* predominates in the tree stratum, with thorny scrub and some thicket as understorey, and a sparse grass fieldlayer. *Albizia petersiana* subsp. *evansii*, *Acacia grandicornuta*, *Gardenia cornuta*, *Dichrostachys cinerea*, *Ehretia rigida*, *Croton menyhartii*, *Azima tetracantha*, *Aloe marlothii*, *Capparis citrifolia* and *Asparagus* spp., are among the more common scrub and thicket-forming plants.

Mahemane Thicket

This covers a great area of the flats and is a dense thicket with *Acacia grandicornuta*, *Albizia petersiana* subsp. *evansii* and *A. anthelmentica* predominating in the tree stratum. The area west of Inyamiti has a canopy averaging 6 to 9 m, elsewhere the height of this type of thicket is variable, as is the species composition. The common larger trees are *Balanites maughamii*, *Pappea capensis*, *Manilkara mochisia*, *Spirostachys africana* and *Ptaeroxylon obliquum*, with scattered *Newtonia hildebrandtii*. Smaller common trees are *Gardenia cornuta*, *Maytenus heterophylla*, *Ehretia rigida*, *Dichrostachys cinerea*, *Acacia luederitzii* var. *retinens*, *Cordia ovalis* and *Euclea* spp., with *Croton menyhartii*, *Euphorbia grandicornis*, *Carissa* spp., *Asparagus* spp., *Ximenia caffra* and *Senecio barber-tonicus* in the shrub layer. The grasses are sparse in dry seasons, but with good rains *Panicum maximum*, *P. deustum*, *Enteropogon monostachyos* subsp. *africanus* and *Sporobolus smutsii* are common.

Throughout the west and on the lower slopes of Ndumu Hill, there are varying formations of the plant species found in the Mahemane.

A feature of the area is the small seasonal pools described under *Aquatic Communities*.

Deciduous broad-leaf woodland

The Hutton red sands of Ndumu Hill carry deciduous broad-leaf open woodland with small scattered thickets, some with Sand Forest species. *Sclerocarya caffra* up to 12 m tall, with *Acacia burkei* and *Terminalia sericea* predominate (canopy at 6 to 10 m). *Strychnos spinosa*, *Strychnos madagascariensis*, *Combretum* spp. (5), *Albizia petersiana* subsp. *evansii*, *Ziziphus mucronata*, *Dialium schlechteri*, *Lannea stuhlmannii*, *Peltophorum africanum*, *Sterculia rogersii*, *Ozoroa obovata*, *Vangueria cyanescens*, *Rhus gueinzii* and *Xeromphis obovata* are all frequent tree species. *Eugenia mossambicensis*, *Salacia kraussii* and *Dichapetalum cymosum* are very common small shrubs forming large communities. *Cassia petersiana*, usually growing as a shrub is on the increase and has spread rapidly in small thickets. The grass cover is generally good, up to 1 m high, and attracts large numbers of animals to the hill. *Panicum maximum*, *Pogonarthria squarrosa*, *Aristida* spp., *Digitaria pentzii*, *Eragrostis superba*, *E. rigidior*, *Sporobolus*

fimbriatus, *Perotis patens*, *Eustachys paspaloides*, *Heteropogon contortus*, *Schmidtia pappophoroides* and *Tricholaene monachne* are common while *Hyperthelia dissoluta* is becoming more widespread.

On the NW slopes, after a number of consecutive seasons with good rains, the drainage lines have formed a "sponge" (which is dissected by the main road) from which tiny streams strickle down towards Inyamiti. A different community of plants, favouring the very wet conditions, can be found here.

Acacia nigrescens Woodland

On the eastern slopes of Ndumu Hill and roughly encircling it on old boulder beds there is *Acacia nigrescens* Thicket. The other larger trees are *Combretum* spp., *Schotia brachypetala*, *Albizia* spp., *Acacia gerrardii*, *A. burkei*, *Galpinia transvaalica*, *Bolusanthus speciosus*, *Peltophorum africanum* and *Berchemia zeyheri*. Smaller trees such as *Ehretia rigida*, *Rhus guezinzi*, *Dichrostachys cinerea*, and shrubs such as *Grewia caffra*, *G. villosa*, and *Croton menyhartii* also occur. The drainage lines have slightly different species, *Spirostachys africana* and *Sideroxylon inerme* among them. *Panicum maximum*, *Heteropogon contortus* and *Themeda triandra* are amongst the most common grasses.

In the west, there is a mosaic of woodland and savanna areas interspersed with shrub and thicket. There are almost pure stands of *Acacia nigrescens* Woodland with scattered large specimens of *Combretum imberbe*, *Lonchocarpus capassa* and *Bolusanthus speciosus*. *Themeda triandra* predominates in the 1 m high grass cover. A feature of the area is the circular grass formations around termitaria. The main constituents of these communities are *Aristida congesta* subsp. *barbicollis*, *Heteropogon contortus* and *Digitaria argyrograptia*, but these grasses have not been adequately collected and it is possible that more species might be present.

Evenly spaced *Acacia nilotica* Woodland with occasional *A. nigrescens* covers a large area. *Panicum maximum* and *Themeda triandra* provide the good grass cover.

A. nilotica and *A. luederitzii* var. *retinens* on wet soils near drainage lines in the west, form a fairly uniform low woodland with *A. senegal*, *Dichrostachys cinerea*, *Albizia petersiana* subsp. *evansii* forming thickets. Grasses are *Panicum maximum*, *P. coloratum* and *Urochloa mossambicensis*.

In an area west of the Mahemane, where *Chloris roxburghiana* is fairly common, *A. nigrescens* is the dominant tree species, and with *Ziziphus mucronata*, *Albizia petersiana* subsp. *evansii*, *A. grandicornuta*, forms an open woodland with scattered thickets of *Cordia ovalis* and *Croton menyhartii*.

There are well-defined seasonal water courses in the west. One of these drains into the western end of Inyamiti pan after passing through the Balemhlanga swamp on the south boundary fence-line. The other flows through from the south-western corner of the reserve, eventually draining into the Usutu floodplain.

Some species commonly found on the Lebombo can be found here, namely *Heteropogon natalensis*, *Bauhinia galpinii* and *Vitex harveyana*.

The rhyolite outcrops in the Mkonjane area are unique in the reserve and, although a very small part of it, are an important protected example of the Lebombo foothills. *Pavetta edentula*, *Acacia caffra*, *Oxalis dissitiflora*, *Pterocarpus rotundifolius* and *Combretum apiculatum* are typical Lebombo mountain species. Mountain and rhyolite grasses and sedge species found here are *Diheteropogon amplexans*, *Sporobolus festivus* var. *fibrosus*, *Tripogon minimus*, *Oropetium capense* and *Mariscus* sp. prob. *M. dubius*.

TABLE 2.

A LIST OF ANGIOSPERM FAMILIES COMPRISING ONE PER CENT AND MORE OF THE TOTAL NUMBER OF SPECIES.

FAMILY	NUMBER OF GENERA	NUMBER OF SPECIES	as % of TOTAL
POACEAE (Graminae)	51	115	13,0
LEGUMINOSAE	35	81	9,1
COMPOSITAE	29	56	6,3
EUPHORBIACEAE	20	43	4,9
LILIACEAE	15	35	3,9
RUBIACEAE	19	35	3,9
CYPERACEAE	10	34	3,8
MALVACEAE	8	24	2,7
ACANTHACEAE	13	22	2,5
ASCLEPIADACEAE	14	22	2,5
CONVOLVULACEAE	7	20	2,3
LAMIACEAE (Labiatae)	12	18	2,0
AMARANTHACEAE	13	15	1,7
CAPPARACEAE	7	15	1,7
CUCURBITACEAE	10	15	1,7
VERBENACEAE	10	13	1,5
COMBRETACEAE	4	13	1,5
COMMELINACEAE	6	12	1,3
APOCYNACEAE	9	12	1,3
TILIACEAE	3	11	1,2
LORANTHACEAE	2	10	1,1
BORAGINACEAE	4	10	1,1
SOLANACEAE	4	9	1,0
CELASTRACEAE	5	9	1,0
ORCHIDACEAE	6	9	1,0

FLORISTICS

Analysis of the flora of Ndumu Game Reserve, based on this checklist, reveals the following plant species: 1 Bryophyte, 4 Pteridophytes, 241 Monocotyledons and 644 Dicotyledons. Angiosperm families comprising 1 per cent and more of the total number of species are listed in order of numerical importance in Table 2. Varieties, sub-species and forms have not been counted unless the record is the

only one for the species to which they refer (if these were to be included the checklist would number over 900 entities).

The largest genera are:

Cyperus, *Acacia* (15); *Eragrostis* (13); *Hibiscus*, *Ipomoea* (11); *Digitaria*, *Asparagus*, *Euphorbia*, *Senecio* (10); *Combretum* (9); *Loranthus*, *Indigofera*, *Helichrysum* (8); *Panicum*, *Sporobolus*, *Grewia*, *Pavetia*, (7); *Phyllanthus*, *Plectranthus*, *Justicia*, *Vernonia* (6); *Setaria*, *Commelina*, *Aloe*, *Albizia*, *Cassia*, *Crotalaria*, *Ceropegia*, *Heliotropium*, *Solanum* (5).

CHECKLIST

The arrangement follows that of the *Flora of Natal* (Ross, 1972), and where additional material is represented it follows the *Genera of Southern African Flowering Plants* (Dyer, 1976). The ferns are arranged according to *Flora Zambesiaca*, *Pteridophyta* (Schelpe, 1970). The numbers in brackets before family names are those used in Ross, and the generic number, from the same source, is listed in the left hand margin next to the first species of the genus.

All herbarium numbers following the specific names are mine except where another collector's initial is attached to the number (an explanation of the initials is listed below). Where no number is supplied, the plant is well known and has been observed but not collected. An asterisk (*) indicates that a plant occurs in the camp or crocodile farm gardens and was transplanted from outside, but nearby the game reserve. Only one collector's number has been listed for each plant although there are often many more specimens in the herbarium.

Some notes on the plants have been included but are entirely random observations, made in Ndumu Game Reserve. Many of the plants must be utilised to a far greater extent by insects, animals and man, but only known personal observations (with some additions from A. C. Pooley) and where indicated, from the herbarium notes of other collectors in the reserve, have been listed. Some information was also extracted from various papers such as Anderson and Pooley (1977), Dixon (1966), Dutton (1972), Oatley (1964), Pooley (1968), Scotcher (1974) and Tinley (1964a).

Some Zulu names of plants with edible fruits have been included, but no attempt has been made to provide a complete list of Zulu names.

Such observations on locality and abundance of plants as are included, are subject to the effect of rainfall, the artificial and irregular flooding of the Pongola river caused by the Jozini dam, and the feeding and trampling effect of the animal populations within the reserve. Reference to locality of plants indicates the area in which they are most commonly found, and are not the only area in which they are found.

Growth form (after Compton, 1966) has been described in the broadest terms, to assist the field worker, and these are defined as:

Trees: a typical tree is a woody plant with a single main trunk. However, some multistemmed woody plants are too well developed to be called shrubs and are listed as trees.

Shrubs: mostly woody plants which do not usually produce a single main trunk, branching from ground level, with many more-or-less equivalent and often interlacing branches. Some single stemmed plants are of small stature and limited development, and have, therefore, been classed as shrubs.

Herbs: this includes a large number of growth forms in which stems are relatively soft, although the lower parts of stems and rootstock can be woody.

Bulbs: perennial plants whose underground resting organs have a swollen form and act as storage receptacles (bulbs, corms, rhizomes).

Succulents: this group includes a variety of plants whose most conspicuous feature is a fleshy thickening of the aerial parts.

Parasites: plants, partially or wholly dependent on the host plant for nutrition.

Epiphytes: plants independent of soil in any quantity and which can absorb water and nourishment from plant debris through clasping and absorbent roots.

Aquatics: includes plants dependent on open water, either free floating, rooted in underwater-mud with flowers and leaves on surface, or completely submerged.

PPdM	P. P. de Moor
HF	H. Furness
JVH	J. V. Hancock
H&B	Hilliard and Burt
EJM	E. J. Moll
ICP	I. C. Player
JHR	J. H. Ross
JSBS	J. S. B. Scotcher
KLT	K. L. Tinley
T&W	Tinley and Ward
CJW	C. J. Ward

BRYPHYTA

HEPATICAE

RICCIACEAE

Ricciocarpus natans (L.) Corda 1653 a Aquatic. Pongola Floodplain; flooded depressions.

PTERIDOPHYTA**EQUISETALES**

- Equisetum ramosissimum* Desf. 1355 Herb. Usutu Floodplain. Frequent on sandy alluvium, amongst grasses.

FILICALES**MARSILIACEAE**

- Marsilia apposita* Launert 1599 Aquatic in seasonal pools. Mahemane.

AZOLLACEAE

- Azolla pinnata* R.Br. 1653 Aquatic. Plentiful in Pongola river.

ADIANTACEAE

- Pellaea viridis* (Forsk.) Prantl 486 Herb. Ulukondo. Sand Forest.

THELYPTERIDACEAE

- Thelypteris dentata* (Forsk.) E. St. John 487 Herb. Usutu Riverine Forest, in damp depressions.

SPERMATOPHYTA**MONOCOTYLEDONEAE****(5) TYPHACEAE**

- 49 *Typha latifolia* L. subsp. *capensis* Rohrb. 1484 Isolated patches on flood-plains, not widespread. Favoured by Thick-billed weaver birds for their nests, which are usually constructed between two stems.

(7) POTAMOGETONACEAE

- 58 *Potamogeton crispus* L. 629 Aquatic. Inyamiti, Banzi Pan, common. Valuable source of food for waterfowl and fish and provides shelter and food for molluscs and aquatic insects.
P. pectinatus L. 491 KLT Aquatic. Inyamiti pan. Valuable source of food for waterfowl and fish and provides shelter and food for molluscs and aquatic insects.

(8) RUPPIACEAE

- 59 *Ruppia maritima* L. 507 KLT Aquatic. Inyamiti pan.

(10) NAJADACEAE

- 64 *Najas marina* L. subsp. *delilei* (Rouy) Maire 3208 CJW Aquatic. Inyamiti pan. Source of food for wildfowl and fish.
N. pectinatus (Parl.) Magnus 457 KLT Aquatic. Banzi pan.

(11) APONOGETONACEAE

- 65 *Aponogeton juncus* Lehm. ex Schlecht. 1577 Aquatic. Uncommon in seasonal pools in Mahemane.

(13) ALISMACEAE

- 72 *Lymnophytum obtusifolium* (L.) Miq. 1575 Aquatic herb. Frequent in seasonal pools in Mahemane.
Burnata enneandra Micheli 1579 Herb. Fairly frequent in seasonal pools in Mahemane (1st record for Natal).

(14) HYDROCHARITACEAE

- 88 *Lagarosiphon verticillifolius* Oberm. 1551 Aquatic. Frequent in seasonal pools in Mahemane.

- 95 *Ottelia exserta* (Ridley) Dandy 1548 Aquatic. Uncommon in seasonal pools in Mahemane. Growing in 1 m of water, leaves floating, flowers erect.

(15) POACEAE (Nom. alt. Gramineae)

- 107 *Coix lacryma-jobi* L. 589 Uncommon. Usutu Floodplain. The nut-like, hard sheaths of inflorescences are used by Tongas as beads.

- 119 *Ischaemum brachyatherum* (Hochst.) Fenzl 1095 Edge of Pongola Floodplain.

- 125 *Urelytrum squarrosom* Hack. 1216 Ndumu Hill. Uncommon in deciduous broad-leaf woodland.

- 126 *Rhytachne robusta* Stapf 895 KLT On drainage lines and in the Balemblanga swamp.

- 127a *Hemarthria altissima* (Poir.) Stapf & C. E. Hubb. 1163 Floodplains. Extensively grazed by hippo and antelope.

- 132 *Elyonurus argenteus* Nees KLT Common in *A. nigrescens* Woodland.

- 134 *Andropogon gayanus* Kunth var. *squamulatus* (Hochst. ex A. Rich.) Stapf 1232 Ndumu Hill. Frequent in deciduous broad-leaf woodland.

- 134A *Sorghum halepense* (L.) Pers. 402 KLT
S. versicolor Anderss. 1618 Mkonjane. Uncommon in *A. nigrescens* Woodland.
S. verticilliflorum (Steud.) Stapf 1427 Common on floodplains. New leaves after burn grazed by hippo. Vervet monkeys eat seeds.

- 134D *Bothriochloa glabra* (Roxb.) A. Camus 1569 Usutu Floodplain. Seasonally flooded depressions.
B. insculpta (Hochst.) A. Camus 781 KLT "Invaded large areas of *Themeda* veld on black loam soils" (KLT).

- 134G *Cymbopogon excavatus* (Hochst.) Stapf ex Burtt Davy 1188 Usutu Floodplain. Common.
C. plurinodis (Stapf) Stapf ex Burtt Davy 868 KLT "*Acacia nigrescens* veld" (KLT).
C. validus Stapf ex Burtt Davy 1318 Scattered communities on Usutu Floodplain.

- 134J *Heteropogon contortus* (L.) Beauv. ex Roem. & Schult. 1047 Widespread on floodplains, in woodland and a constituent of the circular grass communities around termitaria in the west.

- 134N *Diheteropogon amplexens* (Nees) W. D. Clayton 1023 KLT Mkonjane. Common on sandy soil of rhyolite outcrops.

- 134R *Hyperthelia dissoluta* (Nees ex Steud.) W. D. Clayton 558 Usutu Floodplain and common on Ndumu Hill in deciduous broad-leaf woodland. Sometimes cut for thatch for the game reserve. The area under *H. dissoluta* on Ndumu Hill has increased considerably and there is cause for speculation as to whether cutting has aggravated the position.

- 136 *Themeda triandra* Forsk. var. *trachyspatha* Goossens 1319 Widespread; dominating in *Acacia nigrescens* Woodland. Grazed by hippo, rhino and antelope.

- 143 *Tragus berteronianus* Schult. 1223 Widespread. Common on disturbed areas.
- 148 *Perotis patens* Gandoger 562 Ndumu Hill. Frequent on Hutton red sands in deciduous broad-leaf woodland.
- 161 *Paspalum commersonii* Lam. 1179 Floodplains, above flood water level. Hippo and antelope graze it.
P. urvillei Steud. 93 JSBS
P. vaginatum Swartz 1162 Inyamiti pan (an escape from cultivation). Common on edges of pans, forming pure stands.
- 164 *Eriochloa meyeranum* (Nees) Pilg. (syn. *Panicum meyerianum* Nees, also included is *P. meyeranum* Nees var. *grandiglume* Stent & Rattray KLT 508) 578 Grazed by hippo, rhino and antelope. Common on floodplains.
E. nubica (Steud.) Stapf 1244 Inyamiti pan margins. Common on Usutu Floodplain above *Phragmites* line.
E. stapfiana Clayton 1370 Balemhlanga. Common in seasonal pools.
- 166 *Panicum chusqueoides* Hack. 1397 E of Pongola Floodplain, in shade of Sand Forest.
P. coloratum L. 1243 Floodplains, seasonal pools. Grazed by hippo, antelope.
P. deustum Thunb. 1249 Common in Mahemane and Ulukondo—in dense thicket and in Sand Forest. Grazed.
P. infestum Anderss. ex Peters 1592 Ndumu Hill drainage line.
P. kalaharensis Mez 1217 Ndumu Hill. Infrequently scattered in deciduous broad-leaf woodland.
P. maximum Jacq. 559 Widespread and common especially in woodland on Ndumu Hill and in pure stands of *A. tortilis*. Important grazing for hippo, rhino and antelope.
P. subalbium Kunth. (syn. *P. glabrescens* Steud.) 2945 CJW Floodplain. "Common in wet mud" (KLT).
- 166B *Urochloa mosambicensis* (Hack.) Dandy 1254 Widespread; common on disturbed areas. Grazed by hippo and antelope.
U. trichopus (Hochst.) Stapf 962 KLT Usutu Floodplain.
- 166C *Brachiaria nigropedata* (Munro) Stapf 1563 b Ndumu Hill drainage line.
B. xantholeuca (Hack.) Stapf. 1563a N slope, Ndumu Hill. Woodland.
- 166D *Echinochloa colona* (L.) Link. 1457 Pongola Floodplain, on edge of water.
E. holubii (Stapf) Stapf 1262 Common in seasonally inundated pools and depressions.
E. pyramidalis (Lam.) Hitchcock & Chase This species has two distinct growth forms:
1354 "Funga makala"—"erect" form occurs on soil that dries out after summer floods. This form is utilized very little by animals ("hairy form" Ward 2030 according to *Flora of Natal*).
1353 "Mbuku"—"prostrate" form occurs in wet depressions on the floodplain or actually floats at the edges of permanent or semi-permanent pans. It is extensively grazed, particularly by hippo ("glabrous form" Ward 6151 according to *Flora of Natal*).
- 166E *Sacciolepis curvata* (L.) Chase 1221 Ndumu Hill. In deciduous broad-leaf woodland and Sand Forest.
- 166F *Digitaria adscendens* (H.B.K.) Henr. 1384 Ndumu Hill. Deciduous broad-leaf woodland.
D. argyrograpta (Nees) Stapf 1379 A constituent of the circular grass communities around termitaria in the western *A. nigrescens* Woodland.

- Digitaria eriantha* Steud. 1937 JHR Ndumu Hill. Deciduous broad-leaf woodland.
- D. gymnostachys* Pilg. 1651 Ulukondo. Growing on white sand in Sand Forest.
- D. longiflora* (Retz.) Pers. 1587 Ndumu Hill, on seasonally inundated 'sponge' near main gate.
- D. pentzii* Stent 1371 Widespread in woodland and on dry floodplain. Grazed by hippo and antelope.
- D. sp. c.f. smutsii* Stent 54 ICP Inyamiti pan margins. Grazed by hippo. Almost impossible to distinguish from *D. macroglossa* Henr.
- D. swazilandensis* Stent 1627 Floodplains and seasonal pools. Grazed by hippo.
- D. ternata* (A. Rich.) Stapf 56 ICP Inyamiti pan margins. Grazed by hippo. Annual weed.
- D. zeyheri* (Nees) Henr. 1038 Pongola Floodplain margins. Grazed by hippo.
- 168 *Tricholaena monachne* (Trin.) Stapf & C. E. Hubb. 1226 Usutu Floodplain and Ndumu Hill, woodland.
- 168A *Rhynchelytrum repens* (Willd.) C. E. Hubb. 1428 Widespread. Common on margins of roads.
- 169 *Oplismenus hirtellus* (L.) Beauv. JSBS Riverine Forest.
- 171 *Setaria chevalieri* Stapf ex Stapf & C. E. Hubb. 395 Riverine Forest. Grazed by hippo.
- S. neglecta* de Wit 862 KLT Common in *Acacia/Albizia* Thicket in western area.
- S. sphacelata* (Schumach.) Stapf & C. E. Hubb. ex M. B. Moss 18 PPdM
- S. verticillata* (L.) Beauv. 1503 Pongola Floodplain.
- S. woodii* Hack. 1190 Floodplains and seasonally inundated depressions.
- 174 *Cenchrus ciliaris* L. 1805 Disturbed areas.
- 175 *Pennisetum glaucocladum* Stapf & C. E. Hubb. 1426 Infrequent stands on floodplains near water.
- 194 *Leersia hexandra* Sw. 1580 Banzi pan in floating raft of vegetation over 3 m of water.
- 208 *Aristida adscensionis* L. (syn. *A. curvata* (Nees) Trin. & Rupr.) 41 PPdM
- A. canescens* Henr. subsp. *canescens* 617 Usutu Floodplain.
- A. congesta* R. & S. subsp. *congesta* 1016 Widespread in woodland and open grassland. Hippo and antelope graze it.
- A. congesta* R. & S. subsp. *barbicollis* (Trin. & Rupr.) de Winter 998 Widespread in woodland and open grassland. Constituent of the circular grass communities around termitaria in the western *Acacia nigrescens* veld. Grazed by hippo and antelope.
- A. stipitata* Hack. ex Schinz subsp. *graciliflora* (Pilger) Melderis 1235 Widespread in woodland. Grazed by hippo and antelope.
- 230 *Sporobolus consimilis* Fres. 1039 KLT Floodplain margins.
- S. festivus* Hochst. ex A. Rich. var. *fibrosus* Stapf ex Stent 1017 KLT Uncommon on sandy soil in depressions on rhyolite outcrops. Mkonjane.
- S. fimbriatus* Nees forma 1081 Usutu Floodplain. Included is *S. fimbriatus* Nees var. *latifolius* Stent 1300 Common, widespread especially on disturbed areas. Grazed by hippo and antelope.
- S. nitens* Stent 1161 Mahemane, near paths and roads. Grazed by hippo and antelope.

- Sporobolus pyramidalis* Beauv. 1330 Usutu Floodplain.
S. smutsii Stent 1258 Mahemane. Common in thicket. Grazed by hippo and antelope.
S. virginicus (L.) Kunth 1160 Inyamiti pan margins. Extensively grazed by hippo and antelope.
- 282 *Cynodon dactylon* (L.) Pers. 1036 Widespread especially at old kraal sites and disturbed areas; also around Inyamiti where it forms 'lawns' which provide food for geese, hippo and antelope and probably fish when the grass is inundated.
- 287 *Enteropogon macrostachyos* (Hochst. ex A. Rich.) Munro ex Benth. s.n. JSBS
E. monostachyos (Vahl) K. Schum. ex Engl. subsp. *africanus* W. D. Clayton 1. 1 Mahemane Thicket.
- 288 *Chloris gayana* Kunth 587 Floodplains and pan margins. Common. Grazed by hippo and antelope.
C. roxburghiana Schult. 1306 Western area. Locally common in *Acacia nigrescens*/*Albizia evansii* Woodland, west of Mahemane on S boundary.
C. virgata Sw. 619 Floodplains; Bunguzane; Red Cliffs. Grazed by hippo and antelope.
- 288A *Eustachys paspaloides* (Vahl) Lanza & Mattei 999 Widespread, but nowhere abundant.
- 298 *Tripogon minimus* (A. Rich.) Hochst. ex Steud. 1024 KLT Mkonjane, in shallow depressions on rhyolite outcrops.
- 299 *Tetrapogon mosambicensis* (K. Schum.) L. Chippindall ex B. S. Fisher 1389 Seasonal pools, quite common in west.
- 302 *Dinebra retroflexa* (Vahl) Panzer 474 Pongola Floodplain margins.
- 305 *Dactyloctenium australe* Steud. 1642 Ndumu Hill. Woodland.
D. geminatum Hack. 34 PPdM May only be a robust form of the closely allied stoloniferous *D. australe*.
D. giganteum Fisher et Schweickerdt 1206 Ndumu Hill. Frequent in woodland. Grazed. Annual not stoloniferous.
- 307 *Leptochloa panicea* (Retz.) Ohwi 1620 Floodplains.
L. uniflora A. Rich. (syn. *Craspedorachis uniflora* (A. Rich.) Chippindall) 1000 KLT Engabatani. In fairly deep shade of Sand Forest.
- 310 *Enneapogon cenchroides* (Licht.) C. E. Hubb. 1084 Lower slopes of Ndumu Hill in thicket.
E. scoparius Stapf 1423 E of Pongola Floodplain; Mavilo.
- 312 *Schmidtia pappophoroides* Steud. 552 Ndumu Hill. Common in shade in woodland.
- 317 *Triraphis schlechteri* Pilger ex Stent 116 JSBS
- 333 *Phragmites australis* (Cav.) Trin. ex Steud. 516 iHotwe and Sabatane. On floodplains and pan edges.
P. mauritianus Kunth 448 Usutu river banks. On floodplains. Monkeys eat new shoots. Tonga herd boys make flutes from the dried stem of the reed.
- 337 *Diplachne eleusine* Nees 1040 Balemhlanga. Common on drainage lines in west. Widespread in woodland.
D. fusca (L.) Beauv. ex Stapf s.n. JSBS
- 337A *Pogonarthria squarrosa* (Licht.) Pilg. 554 Ndumu Hill. Woodland.

- 337C *Trichoneura grandiglumis* (Nees) Ekman 555 Ndumu Hill. Woodland.
T. sp. 1650 Common on Sand Forest floor in Engabateni, Ulukondo. White sand.
- 341 *Eragrostis aspera* (Jacq.) Nees 1377 Ndumu Hill. Woodland.
E. atherstonei Stapf 1041 Ndumu Hill. Woodland.
E. cilianensis (All.) Lutati 161 Ndumu Hill down to Pongola Floodplain and Inyamiti.
E. ciliaris (L.) R.Br. 613 Widespread in woodland and open grassland.
E. cylindriflora Hochst. (syn. *E. horizontalis* Peter) 1374 Balemhlanga. Seasonally inundated depression.
E. gummiflua Nees 1394 Ndumu Hill. Woodland.
E. heteromera Stapf 1231 Usutu Floodplain. Widespread, especially near seasonally inundated pools, and depressions on floodplain. Grazed by hippo.
E. inamoena K. Schum. 1045 KLT Inyamiti pan margins.
E. pallens Hack. 1227 Ndumu Hill. Woodland.
E. rigidior Pilg. 1234 Ndumu Hill; Usutu Floodplain. Grazed by hippo.
E. rotifer Rendle 1603 Seasonal pools in west.
E. sp. c.f. E. stapfii De Winter 1203 Ndumu Hill. Woodland.
E. superba Peyr. 1017 Widespread in woodland and in open grassland on Usutu Floodplain. Grazed by hippo and antelope.
E. sp. 1327 Usutu Floodplain.
- 398 *Oropetium capense* Stapf 1027 KLT Common on rhyolite outcrops, in shallow depressions. Mkonjane.

(16) CYPERACEAE

Note: In this family species are being moved from one genus to another with what sometimes seems incomplete supporting evidence. *Scirpus* and to a lesser extent *Bulbostylis* are affected. Until the situation is more stabilised, established generic limits have mostly been followed in this list (Dr. K. D. Gordon-Gray).

- 459 *Cyperus articulatus* L. 1630 Near water's edge. Banzi pan margins.
C. denudatus L.f. 1566 Seasonal pools.
C. denudatus var. *sphaerocarpus* (Schrud.) Kük. 1680 Ndumu Hill drainage lines.
C. difformis L. 1625 Balemhlanga. Seasonally inundated depressions.
C. digitatus Toxb. subsp. *auricomis* (Sieber) Kük. 365a Banzi pan margins.
C. distans L.f. 365 Banzi pan margins and seasonally inundated depressions.
C. fastigiatus Rottb. 1180 Common on floodplains. Hippo graze. Used for making sleeping mats.
C. immensus C.B.Cl. 957 KLT Local patches in Mdpine and Ukehla areas, in reedbeds.
C. margaritaceus Vahl 1012 Ndumu Hill. Woodland.
C. nudicaulis Poir. 1639 In floating 'raft' of vegetation on Banzi pan, over 3 m of water.
C. obtusiflorus Vahl 4313 EJM Seasonal sponge on main road near main gate.
C. papyrus L. 624 Scattered patches on floodplains, near pans.
C. rotundus L. 1502 Edge of Pongola Floodplain.
C. rupestris Kunth 1586 Drainage line, Ndumu Hill.
C. sexangularis Nees 1430 Mdpine area. Seasonally flooded depression on Usutu Floodplain.
C. teneriffae Poir. 1166 Scattered in Mahemane Thicket.

- Oxycaryum cubense* (Poep. & Kunth) K. Lye (syn. *Scirpus cubensis* Poeppig & Kunth ex Kunth) 1471 Banzi pan. In floating raft of vegetation, over 3 m depth of water.
- 459A *Pycurus mundtii* Nees 1470 Banzi pan. In floating raft of vegetation, over 3 m of water.
P. pelophilus (Ridl.) C.B.Cl. 1643 On sponge on main road, Ndumu Hill.
P. polystachyos Beauv. 1046 KLT Inyamiti pan.
- 459C *Mariscus* sp. c.f. *M. capensis* Schrad. 1591 Ndumu Hill drainage line.
M. sp. prob. *dubius* (Rottb.) Hutch. 1468 In depressions on rhyolite outcrops. Mkonjane.
M. sp. c.f. *indecorus* (Kunth) Podlech 1593 a & b Ndumu Hill drainage line.
- 462 *Kyllinga alba* Nees 685 JHR Ndumu Hill and *Acacia nigrescens* Woodland on slopes of Ndumu Hill.
K. erecta Schum. 687 JHR Ndumu Hill. Woodland.
- 467 *Fuirena pubescens* (Poir.) Kunth 16 PPdM
F. leptostachya Oliv. 1644 Annual. On sponge on main road, Ndumu Hill.
- 468 *Scirpus articulatus* L. 1623 Balemhlanga. Locally common, in seasonal pools.
S. littoralis Schrad. 1682 Inyamiti pan, in 2 m of water. Used for making sitting mats.
S. muricinux C.B.Cl. 1263 Mahemane. Frequent in seasonal pools.
- 469 *Eleocharis fistulosa* Link 1624 Balemhlanga. Frequent in seasonal pools.
- 471 *Fimbristylis bis-umbellata* (Forsk.) Bub. 840 KLT Usutu Floodplain. Locally abundant.
- 471A *Bulbostylis burchellii* (Fic. & Hiern) C.B.Cl. 611 Usutu Floodplain, Ndumu Hill. Open grassland and woodland.
B. contexta (Nees) Bodard 1943 JHR Ndumu Hill. Woodland.
B. parvinux C.B.Cl. 2015 CJW Ndumu Hill. "Common throughout sandy soil community" (CJW)
- (17) AREACEAE (nom. alt. Palmae)
- 528 *Phoenix reclinata* Jacq. 59/33 PPdM Common along water courses. Seldom growing as tall as at coast. Fruits eaten by bushpig, antelope, monkeys and man (iSundu). Leaves stripped by weaver birds for nests. The stem was tapped in Ndumu for the sweet sap which is used to brew beer. The young fruits attract many insects by day (ants, wasps, bees) and many moths by night. It is difficult to observe what they are all feeding on—they appear to be sucking sap.
- 553 *Hyphaene natalensis* Kuntze 609 Ndumu Hill. Uncommon. Woodland. The fibre from the leaves is used for binding and in the manufacture of baskets (iLala).
- (18) ARACEAE
- 692 *Zamioculcas zamiifolia* (Lodd.) Engl. 1638 Bulb. Ulukondo. Common in Sand Forest.
- 693 *Gonatopus* sp. 322 Bulb. Widespread—occasionally in large communities. Flowering material needed. In woodland, thicket and Sand Forest. Bushpig eat the whole plant.
- 764 *Stylochiton natalense* (Sond.) Schott 741 Bulb. Ndumu Hill. Common in woodland and in Sand Forest where it grows as a much more robust plant.

- 791 *Pistia stratiotes* L. 681 Aquatic. Banzi pan; Mvutsheni pan; Pongola river 'Old Course'. Forms large floating mats.
- (19) LEMNACEAE
- 794 *Spirodela polyrhiza* (L.) Schleid. Aquatic. Common constituent of aquatic floating plant communities on Pongola Floodplain (Musil).
S. punctata (G. F. W. Meyer) Thompson Aquatic. Common constituent of aquatic floating communities on Pongola Floodplain (Musil).
- 796 *Wolffia arrhiza* (L.) Horkel ex Wimmer Aquatic. Common constituent of aquatic floating communities on Pongola Floodplain (Musil).
- (24) COMMELINACEAE
- 896 *Commelina africana* L. 1004 Herb. Common, widespread. Flowers close at noon.
C. benghalensis L. 1265 Herb. Common, Ndumu Hill. Woodland. Flowers close at mid-morning.
C. diffusa Burm.f. 1360 Herb. Common on Pongola Floodplain. Almost exclusive herb in *Cyperus fastigiatus* area of Pongola Floodplain on black clay exposed after flooding. Flowers close at noon.
C. erecta L. 412 Herb. Common, Ndumu Hill. Woodland and Riverine Forest.
C. forskalei Vahl 1634 Herb. Ndumu Hill. Common. Woodland (1st record for Natal).
- 899 *Aneilema dregeanum* Kunth 1399 Common east of Pongola Floodplain in low scrub. Flowers close at night.
A. petersii (Hassk.) C.B.C1. 1808 Herb. Frequent in shade. Ndumu Hill. Woodland.
A. schlechteri K. Schum. 1679 E slope Ndumu Hill. Large communities in woodland. Grazed.
- 899A *Murdannia simplex* (Vahl) Brenan 202 Herb. Ndumu Hill, on drainage lines. Flowers open mid-afternoon, close at sunset. Grow in small clumps. Grazed by antelope.
- 899B *Ballya zebrina* (Chiov.) Brenan 1255 Prostrate herb. Mahemane. Common in thicket.
- 903 *Coleotrype natalensis* C.B.C1. 287 Herb. Ulukondo, common locally in Sand Forest. Open early morning, close late afternoon.
- 904 *Cyanotis speciosa* (L.f.) Hassk. 134 Bulb. Ndumu Hill slopes. Flowers close at midday. When flowers close, stamens curl inwards, pollen first, one over another, then the petals.
- (27) LILIACEAE
- 963 *Gloriosa superba* L. 1825 Bulb, climber with tendrils. Ndumu Hill. Frequent, especially on the edge of thickets where it is protected from browsing antelope.
- 975A *Camptorrhiza strumosa* (Bak.) Oberm. 915 Bulb. Scattered communities on Ndumu Hill. Grows in full sun amongst grasses in woodland.
- 985 *Bulbine asphodeloides* (L.) Roem. & Schult. 37 Herb. Mkonjane, margins of Pongola Floodplain. In *Acacia nigrescens* Woodland. Flowers close at night, not to re-open.
- 989 *Anthericum galpinii* Bak. var. *galpinii* 246 Bulb. Ndumu Hill. Frequent, especially on slopes. Woodland. Flowers open early morning, close midday.

- 989A *Trachyandra saltii* (Bak.) Oberm. var. *secunda* (Krause & Dinter) Oberm. 229 Herb. Common on Ndumu Hill. Woodland. Flowers open early afternoon and close late evening. Grazed.
- 990 *Chlorophytum* sp. c.f. *C. aridum* Oberm. 1420 Herb. Mavilo. In shade of thicket on 'island' in swamps.
C. comosum (Thunb.) Jacques 497 Herb. Widespread in Mahemane Thicket. Browsed by antelope and rootstock eaten by bushpig.
- 1012 *Eriospermum mackenii* (Hook.f.) Bak. 131 Bulb. On seepage line, Ndumu Hill; Mkonjane. Leaves curl up at sides in heat of day. Flowers open towards midday and close after dark. Flower after rain, a number of times a year.
- 1026 *Aloe chabaudii* Schönl. 634 Succulent. Common in Ulukondo. Sand Forest. Leaves and flowering stems browsed.
A. marlothii Berger var. *marlothii* 643 Succulent. Widespread, common, especially in disturbed areas and in *Acacia nigrescens* Woodland. Monkeys, birds, insects (especially bees, ants, flies, beetles) and people suck the nectar. Dry old leaves are used by the Tongas in making snuff.
A. parvibracteata Schönl. var. *zuluensis* (Reynolds) Reynolds 644 Succulent. Widespread, common, sometimes forming large communities. Monkeys eat flower buds. Leaves and flowers browsed by rhino and antelope.
A. rupestris Bak. Succulent. Ulukondo. Rare. In Sand Forests. Large camp garden specimens transplanted from Ulukondo in early 1960s.
A. sessiliflora Pole Evans * Succulent. From Abercorn drift track, on Lebombo foothills just outside game reserve western boundary. Planted in camp and crocodile farm gardens.
- 1079 *Albuca angolensis* Welw. 220 Bulb. Mahemane, Ulukondo. In large communities in thicket and Sand Forest.
A. pachychlamys Bak. 663 Bulb. Mkonjane. In open woodland.
- 1080 *Urginea delagoensis* Bak. 642 Bulb. Mahemane. Frequent but scattered in thicket. Browsed by antelope.
U. epigea R. A. Dyer 3 Bulb. Ndumu Hill. In *Acacia nigrescens* Woodland. Scattered communities. Plants form clumps. Flowers open early morning, close by early afternoon. Browsed by antelope.
U. indica (Roxb.) Kunth var. *multiflora* Oberm. 661 Bulb. Mahemane. Frequent in thicket. Flowers open at about 13h30, close in evening. Common but widely scattered. Leaves and flowers browsed.
U. indica (Roxb.) Kunth (query) 127 Bulb. Ndumu Hill. This plant differs markedly from 661—has different bulb and leaf; fewer, larger flowers; is heavily and unpleasantly scented (661 is unscented); flowers at night (661 opens at midday, closes in the evening). Numerous specimens of both plants occur in the same locality on the margins of Pongola Floodplain and lower Ndumu Hill near the crocodile farm. 127 is common on the sponge on the main road near the main gate. Buds droop downwards, flowers open upwards.
- 1084 *Dipcadi marlothii* Engl. 1583 Bulb. Widespread on Ndumu Hill, not common. Woodland.
D. viride (L.) Moench 476 Ndumu Hill. Woodland. Frequent but scattered. Browsed by antelope.
- 1086A *Ledebouria apertiflora* (Bak.) Jessop 1811 Bulb. Ndumu Hill. Woodland.
L. revoluta (L.f.) Jessop 1812 Bulb. E slope Ndumu Hill in *Acacia nigrescens* Thicket.

- 1089 *Ornithogalum longibracteatum* Jacq. 535 Uluk. 162 Nd. Hill Bulb. Ulukondo; Ndumu Hill. On Ndumu Hill, plants are much smaller in all respects than Ulukondo specimens. In Sand Forest the bulbs grow above the ground. Sap from the bulb stings fiercely. Ndumu Hill bulbs are very much smaller and are deeply buried. Bushpigs and antelope eat entire plant (both forms).
- 1090 *Drimiopsis maculata* Lindl. 35 T&W Bulb. Ndumu Hill in thickets, in woodland.
- 1113 *Asparagus acocksii* Jessop 1137 Climber. Mahemane Thicket. Sickly sweet scent.
A. africanus Lam. 72 Climber. Ndumu Hill. Woodland. Very attractive scent.
A. buchananii Bak. 1348 Climber. Mahemane Thicket.
A. densiflorus (Kunth) Jessop 1145 Herb. Mahemane Thicket. Swollen tubers on roots.
A. falcatus L. var. *falcatus* 847 Climber. Ulukondo; Mahemane. Common in thicket and Sand Forest. Sweetly scented. Browsed by antelope. Monkeys eat shoots and leaves.
A. falcatus L. var. *ternifolius* (Bak.) Jessop 863 Climber. Widespread and common in thicket and woodland. Strongly scented. Browsed.
A. macowanii Bak. var. *zuluensis* (N.E.Br.) Jessop 861 Shrub. Ulukondo, Sand Forest. New spike produced each year which develops into a shrub—dies back after a couple of years.
A. minutiflorus (Kunth) Bak. 1486 Herb. E slope of Ndumu Hill. *Acacia nigrescens* Woodland. Scented.
A. saundersiae Bak. 1152 Climber. Mahemane Thicket.
A. setaceus (Kunth) Jessop 1316 Climber. *Acacia tortilis* Woodland in west.
A. subulatus Thunb. 1138 Climber. Mahemane, locally common in thicket.
A. virgatus Bak. 873 Herb. Ndumu Hill; Mahemane. Woodland and thicket. Monkeys eat whole plant.

(28) AGAVACEAE

- 1110 *Sansevieria desertii* N.E.Br. 1437 Bulb. Mahemane. In thicket, forming large communities. Flowers open in evenings, droop by morning. Scented. Do not flower every year. Spike on tip of leaf raises sore bump on human skin. Occasionally eaten by rhino and antelope.
S. grandis Hook.f. var. *zuluensis* N.E.Br. 1816 Bulb. Ulukondo. Locally common in Sand Forest. Flowers caramel-toffee scented, open in evening. Browsed by nyala.
S. hyacinthoides (L.) Druce 817 Bulb. Widespread, common. Forms large communities especially in disturbed areas in thicket and woodland. Fibre from leaves used for binding twine in manufacture of baskets. Browsed by rhino and antelope. Mole rats eat the rootstock.

(31) AMARYLLIDACEAE

- 1167 *Haemanthus multiflorus* Mart. 660 Bulb. Widespread on Ndumu Hill; also in west, in woodland and thicket. Plants usually found in shade. Leaves appear with flowers. Browsed by antelope. Bushpig eat entire plant.
- 1168 *Boophane disticha* (L.f.) Herb. 982 Bulb. Mkonjane. *Acacia nigrescens* Woodland on rocky ground.
- 1189 *Crinum acaule* Bak. 106 Bulb. Ndumu Hill, woodland, common. Flowers open late afternoon and close at about 08h00 next day. Ovary buried in sand with fruits developing just below or at surface. Leaves continually browsed, and flowers too. They seldom survive the night. Very heavy, lovely scent. Flowers

normally open with storm or rain and plant can bloom a number of times a year. Leaves grow continuously unless browsed. Antelope browse. Bushpigs eat the bulb.

C. delagoense Verdoorn 1502 Bulb. Ndumu Hill, infrequent. Woodland.

C. macowanii Bak. 707 Bulb. Frequent on margins of Pongola Floodplain. Scented. Buds and stem held upwards. As flowers open, stem rests on ground. Flowers open upwards. Some leaves 2 m long and 100 mm wide in deep shade.

C. paludosum Verdoorn 282 Bulb. Frequent in west in seasonal pools and on drainage lines. Faintly scented.

(32) HYPOXIDACEAE

1230 *Hypoxis angustifolia* Lam. 105 Bulb. E slope Ndumu Hill.

H. rooperi S. Moore 662 Bulb. Ndumu Hill. Woodland. Flowers open early and close at midday.

(34) DIOSCOREACEAE

1252 *Dioscorea cotinifolia* Kunth 694 Climber. Mahemane, common. Thicket and Sand Forest. Pretty pink galled fruits found quite frequently.

D. sylvatica (Kunth) Eckl. 539 KLT Climber. In thicket.

(35) IRIDACEAE

1265A *Dietes flavida* Oberm. 657 Herb. Mkonjane. In thicket on rhyolite outcrops. Flowers open late morning and close at dusk. Browsed by antelope.

1311 *Gladiolus dalenii* van Geel 1652 Bulb. Infrequent on Ndumu Hill, in thickets in woodland, (perhaps for protection from bushpigs which eat the bulbs with relish).

G. sp. 1611 Bulb. Banks of Pongola river. More material needed. Flowers large white/pink.

1314 *Lapeirousia grandiflora* Bak. 796 Bulb. Ndumu Hill. Infrequent, usually found on edge of thickets. First day, bud opens slowly, second day open fully, pollen visible—third day pollen lost, flower closes up slowly in afternoon. Drops next day. Orange seeds germinate readily. Bushpig eat the corms.

(38) ORCHIDACEAE

1422a *Bonatea boltonii* (Harv.) Bolus 1398 Bulb. East of Pongola Floodplain in thicket in open woodland.

B. saundersiae Harv. 633 Bulb. Mahemane Thicket. Leaves usually dead at time of flowering. Spur unfurls weeks before flower opens. Browsed by antelope.

1568 *Ansellia gigantea* Reichb. f. var. *nilotica* Summerh. 654 Epiphyte. Mahemane; Ulukondo; Engabatani; east of Pongola Floodplain. Fairly common in Sand Forest and thicket. Huge clumps of roots and pseudobulbs. Scented. Flowers last a long time (weeks). Known by Tongas as the 'monkey's sugar cane' because the monkeys eat the plant. Large clumps were placed in trees in the camp in the early 1960's.

1648 *Eulophia hereroensis* Schltr. 96 Bulb. Ulukondo. In Sand Forest and thickets in woodland. Bushpig eat the rootstock.

E. leachii Greatrex ex Hall 304 Bulb. Mahemane Thicket. Flowers appear with new leaves. Browsed by antelope.

E. petersii Reichb.f. 175 Bulb. Mahemane; Mkonjane. In thicket and on rhyolite outcrops in west. Grow in large clumps—inflorescences will grow to a height of 2 m and more (when in shade) to reach the light.

- 1835a *Cyrtorchis praetermissa* Summerh. 1202 Epiphyte. Ulukondo, Sand Forest. Not common, found in valley-mist areas.
- 1837 *Mystacidium capense* (L.f.) Schlechter 852 Epiphyte. Ulukondo Sand Forest. In valley-mist belt, seldom found below 2 m. Scented at night.
- 1837a *Microcoelia exilis* Lindl. 353 Epiphyte. Ulukondo Sand Forest and on trees adjacent to Inyamiti and Banzi pans.

DICOTYLEDONEAE

(43) ULMACEAE

- 1902 *Trema orientalis* (L.) Bl. 839 Tree. Usutu Floodplain and in disturbed areas in Riverine Forest. Birds eat fruits. Browsed by antelope. Young plants in shade of forest can have very large leaves.

(44) MORACEAE

- 1961 *Ficus capreifolia* Del. 398 Shrub. Floodplains and especially the Pongola river banks. Browsed. Used for making Fonya fishing baskets and the leaf is used as sandpaper by the Tongas when carving household utensils.
- F. sycomorus* L. 823 Tree. Floodplains and Riverine Forest. Trees can be found fruiting at almost any time of the year. The fruits can be very sweet. The Tongas mash them up with water when food is scarce at the end of winter. Birds, monkeys, bushbabies, antelope, bushpig and people eat the figs (umKhiwane). The leaves are browsed by antelope. Ripe fruits are used as bait for catching barbel.

(46) URTICACEAE

- 1980 *Laportea peduncularis* (Wedd.) Chew 396 Shrub. Usutu Riverine Forest.

(48) LORANTHACEAE—the family is attractive to sunbirds.

- 2074 *Loranthus bolusii* Sprague 1675 Parasite. Ndumu Hill. Thicket in woodland and in pan-edge community on *Acacia grandicornuta*.
- L. dregei* Eckl. & Zeyher 872 Parasite. Pongola Floodplain, Ndumu Hill. On *Trichilia emetica*.
- L. kalachariensis* Schinz 1364 Parasite. Ndumu Hill. On *Acacia burkei*.
- L. kraussianus* Meisn. 812 Parasite. Mahemane Thicket, floodplains (in thickets).
- L. minor* (Harv.) Sprague 1676 Parasite. S bank Inyamiti in thicket. On *Maytenus heterophylla*. Faintly scented.
- L. ngamicus* Sprague 801 Parasite. Mahemane Thicket. On *Acacia tortilis*.
- L. oleaeifolius* Cham. & Schlecht. 702 JHR Parasite. Ndumu Hill. on *Acacia burkei*.
- L. quinquenervis* Hochst. 1436 Parasite. Mahemane Thicket.
- 2093 *Viscum spragueanum* Burt Davy 1481 Parasite. Ndumu Hill. On *Strychnos spinosa*.
- V. verrucosum* Harv. 1363 Parasite. Mahemane Thicket on *Acacia grandicornuta*. Forms large masses 1 m in diameter.

(49) SANTALACEAE

- 2118 *Thesium* sp. 1660 Herb. Ndumu Hill. Woodland.
- Thesium* sp. 139 Herb. Mahemane Thicket. Common.

(50) OLACACEAE

- 2131 *Olex dissitiflora* Oliv. 1388 Tree. Mkonjane. Uncommon in *Acacia nigrescens* Woodland.

- 2136 *Ximenia caffra* Sond. var. *natalensis* Sond. 1173 Shrub. Mahemane Thicket. Fruits eaten by monkeys, birds and man (amaThunduluka). No. 715, from Ndumu Hill where it is common, differs in leaf colour and size but good flowering material is needed for correct determination.

(52) POLYGONACEAE

- 2201 *Polygonum aviculare* L. 1035 Herb. Edge of Banzi pan.
P. plebeium R.Br. 528 KLT Herb. Dried mudflats.
P. pulchrum Blume 200 Herb. Pongola Floodplain. Common.
P. senegalense Meisn. forma *albotomentosum* R. Grah. 1358 Herb. Pongola Floodplain. Common in scattered patches.
- 2204 *Oxygonum dregeanum* Meisn. var. *dregeanum* 1809 Herb. Ndumu Hill. Common in woodland.

(53) CHENOPODIACEAE

- 2223 *Chenopodium album* L. 297 Herb. Ndumu Hill. Very common in woodland especially on disturbed ground. Unpleasant scent.
C. ambrosioides L. 491 Herb. Usutu River banks. Common.
- 2255 *Arthrocnemum natalense* (Bunge ex Ung-Sternb.) Moss var. *natalense* 460 KLT Inyamiti pan, mudflats. Uncommon.
- 2257 *Salicornia pachystachya* Bunge ex Ung-Sternb. 888 Succulent herb. Inyamiti mudflats and stream. Browsed by antelope.

(54) AMARANTHACEAE

- 2292 *Celosia trigyna* L. 1649 Herb. Ulukondo, locally common. Sand Forest.
- 2293 *Hermboetia odorata* (Burch.) T. Cooke 149 Herb. Widespread especially in disturbed areas. Thorny fruit.
- 2299 *Amaranthus thunbergii* Moq. 1508 Herb. Common on Ndumu Hill; margins Pongola Floodplain—on disturbed soil.
- 2309 *Cyphocarpa angustifolia* Lopr. 1198 Herb. Red Cliffs. *Acacia tortilis* Thicket. Bunguzane. Browsed by nyala.
- 2311 *Centema subfusca* (Moq.) Lopr. 19 TBO *Acacia xanthophloea* Forest, east of Banzi pan.
- 2312 *Cyatula spathulifolia* Lopr. 846 Herb. Ulukondo. Common in Sand Forest. Burr fruit.
- 2314 *Pupalia atropurpurea* Moq. 719 Scandent herb. Widespread, common especially in thickets. Clinging burr fruit.
Nothosaerva brachiata (L.) Wight 1560 Herb. Mahemane pools (1st record for Natal).
- 2324 *Psilotrichum africanum* Oliv. 733 Herb. Ulukondo. On edge of Sand Forest.
- 2328 *Achyranthes aspera* L. 465 Herb. Ndumu Hill, in thicket; Riverine Forest. Common.
A. sicula (L.) All. 1310 Herb. Mahemane Thicket; *Acacia tortilis* Woodland.
- 2328a *Achyropsis leptostachya* Hook.f. 1195 Herb. Margins of floodplains.

- 2335 *Alternanthera pungens* H.B.K. 1507 Prostrate herb. Widespread especially on disturbed ground. 'Paper thorns'.
A. sessilis (L.) DC. 421 KLT "Common emergent aquatic, usually in water up to 6 m deep" (KLT)

- 2338 *Gomphrena celosioides* Mart. 1595 Herb. Mahemane, widespread. On edges of seasonal pools.

(55) NYCTAGINACEAE

- 2347a *Commicarpus africanus* (Lour.) Dandy 666 Common on south boundary fence-line in the west. Herb.

- 2349 *Boerhavia diffusa* L. var. *hirsuta* Heim. ex descr. 415 Herb. Common on Ndumu Hill. Woodland. Fruits stick to clothing.

- 2354 *Pisonia aculeata* L. 1418 Climber. Common in Riverine Forest. No flowers or fruits have been collected at Ndumu.

(57) MOLLUGINACEAE

- 2376 *Limnium fenestratum* (Fenzl) Heimerl 754 Herb. Ndumu Hill, woodland. Common.

L. viscosum (J. Gay) Fenzl subsp. *viscosum* var. *glomeratum* (Eckl. & Zeyher) Freidr. 1238 Herb. Ndumu Hill, drainage lines.

- 2382 *Gisekia africana* (Lour.) O. Kuntze var. *africana* 150 Prostrate herb. Edge of Pongola Floodplain. Common.

G. africana (Lour.) O. Kuntze var. *cymosa* Adamson 296 Herb. Ndumu Hill. Common. Woodland.

Mollugo nudicaulis Lam. 1552 Herb. Seasonal pools. Common (1st record for Natal).

- 2388 *Glinus oppositifolius* A.DC. 364 Herb. Banzi pan margins.

- 2390 *Hypertelis bowkeriana* Sond. ex descr. 1607 Herb. Bunguzane. Thicket, on disturbed ground.

- 2393a *Corbichonia decumbens* (Forsk.) Exell 360 Herb. East slope Ndumu Hill; *Acacia nigrescens* Woodland along base of Ndumu Hill. Flowers open midday to sunset and re-open next day.

(58) AIZOACEAE

- 2395a *Zaleya pentandra* (L.) Jeffrey 94 Herb. Common in Mahemane Thicket.

- 2403 *Tetragonia expansa* Thunb. 1465 Herb. Pongola Floodplain margin (introduced).

(59) MESEMBRYANTHEMACEAE

- 2405 *Aptenia cordifolia* (L.f.) N.E.Br. 13 TBO Herb. Thicket.

- 2405 *Delosperma lebomboense* (L. Bol.) Lavis 1266 Herb. Common in Mahemane Thicket.

(60) PORTULACACEAE

- 2406 *Talinum caffrum* (Thunb.) Eckl. & Zeyher 303 Herb. Widespread in thicket and woodland. Flowers open afternoon to night. Plants die back in winter, re-shoot from carrot-like rootstock. Bushpig eat the rootstock.

Talinum portulacifolium (Forsk.) Aschers. ex Schweinf. 201 Succulent herb. Ulukondo, locally common on edge of Sand Forest and thicket. Flowers open at about 15h30 and close in late afternoon. Blooms all summer and dies back in winter to re-shoot from same rootstock—swollen roots, not as well developed as the previous species. Browsed by antelope.

- 2419 *Portulacaria afra* Jacq. 842 Succulent shrub. Widespread, particularly at old kraal sites. Occasionally browsed.

- 2421 *Portulaca pilosa* L. 1277 Herb. Mahemane Thicket.
P. quadrifida L. 1636 Herb. Mahemane Thicket.

(61) BASELLACEAE

- 2424 *Basella paniculata* Volkens 4891 EJM Climber. Mahemane Thicket.

(63) ILLECEBRACEAE

- 2465 *Pollichia campestris* Ait. 295 Herb. Ndumu Hill. Common in woodland on Hutton red sands.

(64) NYMPHAEACEAE

- 2513 *Nymphaea capensis* Thunb. 585 Aquatic. Widespread in pools and pans. Flowers remain open for some days. Heavy scent, stronger at night. Hippo eat tubers, monkeys eat exposed roots on mudflats. Tubers collected by Tongas to take home and cook (amaZibo).
N. lotus L. 765 Aquatic. Banzi pan, Inyamiti stream. Flowers open at night, close mid-morning. Tubers eaten by man and beast—see above (amaHlolwane).

(65) CERATOPHYLLACEAE

- 2516 *Ceratophyllum demersum* L. 1758 EJM "Submerged aquatic in open fresh water" (EJM).

(66) RANUNCULACEAE

- 2546 *Ranunculus multifidus* Forsk. 165 Herb. Floodplains. Common.

(67) MENISPERMACEAE

- 2570 *Cocculus hirsutus* (L.) Diels 545 Climber. Widespread, common especially in woodland. Browsed.
 2574 *Cissampelos hirta* Klotzsch 2016 CJW Climber. Ndumu Hill. Common. Woodland. Browsed.
C. torulosa E. Mey. ex Harv. 86 Climber. Ndumu Hill. Woodland.
 2643 *Epinetrum delagoense* (N.E.Br.) Diels 529 Climber. Ndumu Hill, woodland. Forms dense communities. Fruits eaten by Tongas (inGantaganta).

(68) ANNONACEAE

- 2673 *Uvaria caffra* E. Mey. ex Sond. 783 Climber. Ulukondo. Sand Forest.
U. lucida Benth. subsp. *virens* (N.E.Br.) Verdc. 1003 KLT Climber. Engabateni. Sand Forest.
 2696 *Monanthes affra* (Sond.) Verdc. 450 Climber. Widespread, common in woodland and thicket. Browsed by antelope. Birds eat the fruits.
 2733 *Monodora junodii* Engl. & Diels 1412 Tree. Ulukondo, Sand Forest and occasional along the Pongola Floodplain. Fruits eaten by Tongas (umKhotshi).

(70) LAURACEAE

- 2813 *Cryptocarya woodii* Engl. 847 KLT Pongola Riverine Forest.
 2825 *Cassytha filiformis* L. 1622 Climber. Ndumu Hill. Frequent in woodland.

(71) PAPAVERACEAE

- 2852 *Argemone mexicana* L. 75 Herb. Usutu Floodplain (introduced).
 (73) BRASSICACEAE (nom. alt. Cruciferae)
 2883 *Lepidium africanum* (Burm.f.) DC. 1439 Herb. Ndumu Hill. Common on disturbed ground.
 2965a *Rorippa madagascariensis* (DC.) Hara 1464 Herb. Common on Pongola Floodplain.

(74) CAPPARACEAE

- 3082 *Cleome angustifolia* Forsk. subsp. *diandra* (Burch.) Kers. 391 Herb. Ndumu Hill. Frequent in woodland. Flowers close at midday.
C. monophylla L. 370 Herb. Pongola Floodplain margins. Common. Flowers close midday.
 3099 *Cladostemon kirkii* (Oliv.) Pax & Gilg 29 Tree. Ndumu Hill, towards Bunguzane and S bank Inyamiti; Ulukondo. Flowers open green, turning white then yellow, petals veined in green. Scented. Flowers appear with new leaves. Browsed by antelope. Roots spread out horizontally from tree. Small piece of root will grow into a tree. Afflicted by a borer. Ripe fruits stink.
 3101 *Capparis brassii* DC. 108 Climber. Mahemane, widespread in thicket. Browsed by antelope.
C. fascicularis DC. var. *fascicularis* 628 Climber. Mahemane Thicket. Pleasantly scented flowers.
C. sepiaria L. var. *citrifolia* (Lam.) Toelken 1267 Scandent shrub. Mahemane Thicket. Particularly common in *Acacia tortilis* Thicket.
C. tomentosa Lam. 85 Climber. Common, especially on floodplains. Widespread. Flowers wilted by early afternoon. Fruits eaten by monkeys and man (umQokolo, uKokwane). Browsed by nyala.
 3106 *Boscia albitrunca* (Burch.) Gilg & Ben. 1197 Tree. Widespread. Much browsed. Insects and birds enjoy the flowers and fruits.
B. foetida Schinz subsp. *rehmanniana* (Pest.) Toelken 833 Shrub. Mahemane, Ulukondo. Thicket and Sand Forest. Sickly sweet scent. Browsed by antelope.
 3109 *Cadaba natalensis* Sond. 826 Shrub. Widespread, particularly in thicket and woodland. Browsed by antelope.
 3112 *Maerua angolensis* DC. 721 Tree. Mahemane. Thicket and woodland. Browsed by antelope.
M. edulis (Gilg & Ben.) De Wolf 79 Shrub. Mahemane Thicket. Common on roadsides.
M. juncea Pax subsp. *crustata* (Wild) Wild 219 Climber. Mahemane. Thicket and woodland. Flowers open for a day. Faintly scented. Fruits orange when ripe. Browsed by nyala.
M. rosmarinoides (Sond.) Gilg & Ben. 581 KLT Shrub. Bunguzane.
 3113 *Thylachium africanum* Lour. 80 Shrub. Widespread; common in woodland, thicket and Sand Forest. Flowers close after a day. Much browsed by all antelope. Flowers white becoming pink. Fruits eaten by Tongas (isiKonke).

(79) CRASSULACEAE

- 3164 *Cotyledon wickensii* Harv. 520 Succulent. Mahemane Thicket.
- 3166 *Kalanchoe rotundifolia* Haw. 14 Succulent. Widespread. Common, especially in thicket. Browsed.
K. rotundifolia (Haw.) Harv. var. *peltata* Raymond-Ham. 307 Succulent. Ndumu Hill. Uncommon. Woodland. Browsed.
K. sp. 580 Succulent. Mkonjane; E slope Ndumu Hill. *Acacia nigrescens* Woodland. Plant takes 2 to 3 years to mature. Dies back after flowering but re-shoots from base.
- 3168 *Crassula portulaca* Lam. 16 Succulent. Mahemane Thicket and Sand Forest.
C. transvaalensis Kuntze 288 Herb. Ndumu Hill. Infrequent. Woodland.
C. sp. 468 Herb. Inyamiti pan margins; Ulukondo; Mahemane. Common in thicket and Sand Forest.

(87) ROSACEAE

- 3353 *Rubus rigidus* Smith 171 Climber. Pongola Floodplain. Fruits eaten by birds and Tongas (uGagane).

(90) LEGUMINOSAE

- 3443 *Albizia adianthifolia* (Schumach) W. F. Wight 1414 Tree. E of Pongola Floodplain.
A. anthelmintica (A. Rich.) A. Brongn. 649 Tree. Dominant in Mahemane; elsewhere in thicket. Conspicuous in August/September when in full flower without leaves. Lovely scent. Browsed by antelope.
A. forbesii Benth. 1403 Tree. Ulukondo. Sand Forest. Browsed.
A. petersiana (Bolle) Oliv. subsp. *evansii* (Burt Davy) Brenan 980 Tree. Ndumu Hill. Woodland; widespread. Browsed by antelope. Trees have coppery spring foliage.
A. versicolor Welw. ex Oliv. 710 Tree. Ndumu Hill. Woodland. Flowers appear on new shoots. Attractive scent. Parrots eat seeds out of pods.
- 3446 *Acacia albida* Del. 3151 CJW Tree. Usutu Floodplain. Uncommon. Some very large specimens.
A. borleae Burt Davy 825 KLT Tree. Isolated patch on road from main gate to Inyamiti.
A. burkei Benth. 527 Tree. Ndumu Hill. Woodland, very common. Flowers unpleasantly scented. Favoured for bird nests perhaps because of the protective vicious thorns. Gum eaten by monkeys and Tongas. Browsed by antelope.
A. caffra (Thunb.) Willd. 655 JHR Tree. Mkonjane. Not common, in *Acacia nigrescens* Woodland.
A. gerrardii Benth. var. *gerrardii* 1382 Tree. Frequent in western area, scattered elsewhere in woodland and thicket.
A. grandicornuta Gerstner 1177 Tree. Mahemane. Dominant. Widespread in thicket. Browsed.
A. kraussiana Meisn. ex Benth. 1401 Climber. E of Pongola Floodplain on edges of Sand Forest.
A. luederitzii Engl. var. *retinens* (Sim) Ross & Brenan 1125 Tree. Mahemane. Thicket and woodland near drainage lines in west.
A. nigrescens Oliv. 897 KLT Tree. Common in the western area; Ndumu Hill slopes. Browsed.
A. nilotica (L.) Willd. ex Del. subsp. *kraussiana* (Benth.) Brenan 1270 Tree. Ndumu Hill. Widespread, dominant in parts of west. Beautiful scent. Monkeys eat flowers; monkeys and people eat the gum. Browsed.

- Acacia robusta* Burch. subsp. *clavigera* (E. Mey.) Brenan 790 KLT Tree. Margins of pans, floodplains.
- A. schweinfurthii* Brenan & Exell var. *schweinfurthii* 1400 Climber. Riverine Forests. Leaves close in dark or when picked.
- A. senegal* (L.) Willd. var. *rostrata* Brenan 1158 Shrub. Widespread but not common. Browsed.
- A. tortilis* (Forsk.) Hayne subsp. *heteracantha* (Burch.) Brenan 595 Tree. Widespread, common—forms pure stands. Browsed. Dried seed pods eaten by antelope.
- A. xanthophloea* Benth. 696 JHR Tree. Floodplains, forms pure stands at Shokwe and Banzi. Monkeys eat leaves, buds, flowers, seeds.
- 3449 *Mimosa pigra* L. 166 Shrub. Pongola Floodplain.
- 3452 *Dichrostachys cinerea* (L.) Wight & Arn. Two different forms found on Ndumu Hill, woodland; KLT 785 (large leaf) becoming tree-like with black striated bark. ESP 964 (small leaf) remains a many stemmed shrub. Browsed. Nyala eat seed pods. Monkeys eat seeds.
- 3460 *Newtonia hildebrandtii* (Vatke) Torre var. *hildebrandtii* 1111 Tree. Dominant in Ulukondo. Sand Forest. Pink-winged seeds litter the forest floor beautifully.
- 3506 *Schotia brachypetala* Sond. 12 Tree. Ndumu Hill, edge of floodplains. Many insects and birds, particularly sunbirds, attracted to flowers. Flowers appear with the new leaves. Leaves browsed. Monkeys eat flower buds. Bark of tree used to dye Tonga fish nets.
- S. capitata* Bolle 1093 Tree. Mahemane, in thicket. Browsed. Sunbirds particularly attracted to flowers.
- 3509 *Azelia quanzensis* Welw. 1438 Tree. East of Pongola Floodplain. One young specimen in *Acacia xanthophloea* Forest at Banzi, perhaps seed brought down by floods (from Lebombo mountains).
- 3528 *Bauhinia galpinii* N.E.Br. 1655 Shrub. Fontana pan margins, Paphekulu stream. Scandent shrub. Planted in camp and crocodile farm gardens.
- 3530 *Dialium schlechteri* Harms 156 Tree. Ndumu Hill. Woodland, Sand Forest. Heavy rather unpleasant scent. People, monkeys and birds eat the fruits (umThiba).
- 3536 *Cassia bicapsularis* L. 641 Scandent shrub. Usutu Riverine Forest.
- C. italica* (Mill.) Lam. ex F. W. Anders subsp. *arachoides* (Burch.) Brenan 92 Sub-woody plant, Ndumu Hill. Woodland. Frequently found on roadsides.
- C. mimosoides* L. sens. lat. 716 Herb. Ndumu Hill. Woodland. Frequent.
- C. occidentalis* L. 405 Shrub. Usutu Floodplain.
- C. petersiana* Bolle 499 Shrub. Common on Ndumu Hill. Woodland. Sweetly scented. Monkeys eat green pods. Birds eat seeds. Tongas eat seeds (umNem-benembe). Browsed. Forms thickets on the hill and spreads quickly giving cause for concern.
- C. siamea* Lam. 1515 CJW Tree. At old kraal site, Usutu Floodplain.
- 3551 *Parkinsonia aculeata* L. JEWD Tree. Catuane crossing. Riverine Forest (introduced).
- 3561 *Peltophorum africanum* Sond. Tree. Ndumu Hill. Woodland.
- 3607a *Bolusanthus speciosus* (Bolus) Harms 19 Tree. Widespread, in woodland and on edges of Usutu Floodplain. Flowers appear with new leaves. Faintly scented.

Small worms eat colour off flowers and the leaves. Flower buds eaten by vervet monkeys.

- 3669 *Crotalaria* near *C. burkeana* Benth. 429 Herb. S slope Ndumu Hill. Woodland.
C. monteiri Taub. ex Bak.f. 203 Shrub. Ndumu Hill; Usutu Floodplain. Browsed.
C. natalensis Bak.f. TBO Herb. SW corner of reserve.
C. pallida Ait. var. *pallida* 534 Herb. Pongola Floodplain.
C. sphaerocarpa Perr. ex DC. 416 Herb. Ndumu Hill. Frequent. Woodland, in shade.
- 3688 *Medicago aschersoniana* Urb. 1693 Herb. Ulukondo, Sand Forest. Browsed.
- 3702 *Indigofera arrecta* Hochst. ex A. Rich. 1281 Herb. Usutu Floodplain. Mahemane clearing.
I. charleriana Schinz var. *charleriana* 1442 Herb. Pongola Floodplain margin.
I. charleriana Schinz var. *sessilis* (Chiov.) Gillett 1589 Herb. Pongola Floodplain margin.
I. costata Guill. & Perr. subsp. *macra* (E. Mey.) Gillett 1252 Herb. Wide-spread.
I. delagoensis Bak.f. ex Gillett 1554 Herb. Ndumu Hill. Common. Woodland.
I. filipes Benth. ex Harv. 1590 Herb. Ndumu Hill drainage line.
I. schimperi Jaub. & Spach var. *schimperi* 664 Herb. Mkonjane. Common on disturbed areas.
I. spicata Forsk. 169 Herb. Pongola Floodplain. Frequent.
I. vicoides Jaub. & Spach var. *rogersii* (R. E. Fries) Gillett 1565 Herb. Mahemane pools.
- 3718 *Tephrosia forbesii* Bak. subsp. *inhacensis* Brummitt 363 Herb. Ndumu Hill. Woodland. Flowers open mid-afternoon. Browsed.
T. longipes Meisn. subsp. *longipes* 753 Herb. Ndumu Hill; Mkonjane. Woodland. Browsed.
T. semiglabra Sond. 1582 Herb. Ndumu Hill. Common. Woodland.
T. sp. 1259 Herb in *Acacia tortilis* Woodland.
T. sp. 1285 Herb. Ndumu Hill, woodland.
T. sp. 308 Herb. Ndumu Hill, woodland.
- 3719 *Mundulea sericea* (Willd.) A. Chev. 674 Shrub. Ndumu Hill; Mkonjane. Woodland. Browsed by antelope.
- 3720a *Craibeia zimmermannii* (Harms) Harms ex Dunn 696 Tree. Ulukondo, Sand Forest. Beautiful when in flower, scented.
- 3747 *Sesbania sesban* (L.) Merrill subsp. *sesban* var. *nubica* Chiov. Pongola Floodplain. There appear to be distinct varieties:
541—Perennial tree, with many leaves.
170—Annual shrub, with few leaves.
- 3792 *Ormocarpum trichocarpum* (Taub.) Engl. 427 Small tree. Ndumu Hill. Woodland. Browsed.
- 3802 *Stylosanthes fruticosa* (Retz.) Alston 1236 Herb. Ndumu Hill. Woodland.
- 3804 *Zornia capensis* Pers. 1692 Herb. Ndumu Hill. Woodland.
- 3810 *Alysicarpus glumaceus* (Vahl) DC. non (Roth) Schindl. 726 Herb. Pongola Floodplain margins.

- 3821 *Dalbergia armata* E. Mey. Climber. Riverine Forest.
D. obovata E. Mey. 1214 Tree. Ndumu Hill. Infrequent. Woodland.
D. sp. c.f. *D. nitidula* Welw. ex Bak. 1659 Scandent shrub. Common in Ulukondo. Sand Forest. Collected in flower and pod in February, 1972—the first such flowering and fruiting observed in four years. Flowers appear without leaves. Scented. Browsed.
- 3828 *Pterocarpus angolensis* DC. TPD Tree. Usutu river bank. Rare.
P. rotundifolius (Sond.) Druce subsp. *rotundifolius* 1032 KLT Shrub. Mkonjane.
- 3834 *Lonchocarpus capassa* Rolfe 1286 Tree. Scattered in western areas.
- 3856 *Abrus laevigatus* E. Mey. 243 Climber. Mkonjane. Thickets in *Acacia nigrescens* Woodland and on rhyolite outcrops.
A. precatorius L. subsp. *africanus* Verdc. 572 Climber. Floodplains and Ndumu Hill. Seeds used for decoration by Tongas—in musical instruments and clay pots.
- 3864 *Glycine wightii* (R. Grah. ex Wight & Arn.) Verdc. 1315 Climber. Usutu Floodplain. *Acacia tortilis* Woodland. In shade of continuous canopy of forest patches.
- 3870 *Erythrina humeana* Spreng. 815 Shrub with large swollen underground root. Ndumu Hill, woodland. Usually protected in thickets from browse, fire.
E. lysistemon Hutch. Tree. Usutu Floodplain at old kraal sites.
- 3891 *Canavalia virosa* (Roxb.) Wight & Arn. 1362 Climber. Pongola Riverine Forest.
- 3892 *Cajanus cajan* (L.) Millsp. 1347 Herb. Usutu Floodplain.
- 3897 *Rhyncosia minima* (L.) DC. var. *minima* 720 Climber. Common on Ndumu Hill. Flowers closed in afternoon.
R. minima (L.) DC. var. *prostrata* (Harv.) Meikle 1615 Climber. S boundary, in west.
R. totta (Thunb.) DC. var. *totta* 722 Climber. Pongola Floodplain.
- 3898 *Eriosema psoraleoides* (Lam.) G. Don 1342 Shrub. Floodplains. Forms occasional communities. Tongas collect seeds in large quantities, take home and cook mixed with mealie meal, etc. (uTongolo).
- 3905 *Vigna luteola* (Jacq.) Benth. 358 Climber. Banzi pan, on floating rafts of vegetation.
V. unguiculata (L.) Walp. var. *protracta* (E. Mey.) Verdc. 252 Climber. Ndumu Hill. Common in woodland. Flowers close before noon. Browsed. Tubers on roots eaten by Tongas.
V. vexillata (L.) Rich. sens. lat. 173 Climber. Pongola Floodplain.
- 3910 *Dolichos trilobus* L. subsp. *transvaalicus* Verdc. 600 Climber. Usutu Floodplain.
- 3910d *Macrotyloma axillare* (E. Mey.) Verdc. 1654 Climber. Ndumu Hill. On the 26/2/72 (ESP) and 25/3/55 (ICP) this creeper covered the grasses and shrubs of Ndumu Hill to the point of 'suffocation'—bleaching of grasses. Browsed, or eaten with grasses by nyala.
M. maranguense (Taub.) Verdc. 1824 Climber. Ndumu Hill. Tubers on roots dug up and eaten by Tongas, raw and cooked. Bushpigs also dig up to eat (isiKhondle).

(91) GERANIACEAE

- 3928 *Pelargonium* sp. 2564 CJW Herb. Ndumu Hill.

(92) OXALIDACEAE

- 3936 *Oxalis corniculata* L. 709 Herb. Ndumu camp. (Weed) spread by birds which eat seeds.
O. semiloba Sond. subsp. *semiloba* 1292 Herb. Scattered communities on Ndumu Hill and in the west, on roadsides. Flowers close mid-afternoon.

(94) ERYTHROXYLACEAE

- 3956 *Erythroxylon emarginatum* Thonn. 1677 Tree. Ulukondo. Sand Forest.

(95) ZYGOPHYLLACEAE

- 3978 *Tribulus terrestris* L. 1602 Herb. Ndumu Hill, Pongola Floodplain. On disturbed ground. 'Devil Thorn.'

(96) BALANITACEAE

- 3980 *Balanites maughamii* Sprague 591 Tree. Mahemane Thicket. Common. Browsed. Nyala and monkeys eat fruits.
B. pedicellaris Mildr. & Schltr. 311 Tree. Mahemane. Common in thicket.

(97) RUTACEAE

- 4076 *Vepris carringtoniana* Mendonca 685 Shrub. Mahemane near main gate and S boundary fence. Only known locality in Natal.
 4078 *Toddaliopsis bremekampii* Verdoorn 860 Shrub. Ulukondo. Frequent in Sand Forest.
 4091 *Clausena anisata* (Willd.) Hook.f. ex Benth. 809 Shrub. Widespread in thicket. Heavy unpleasant scent when leaf or stem is broken. Browsed.

(98) BURSERACEAE

- 4151 *Commiphora neglecta* Verdoorn 508 Tree. Ndumu Hill—frequently in large communities in woodland, forming thickets. Browsed. Many species of bird eat the fruits. Tree trunks cut and dried to make floats for fishing nets. Swollen roots dug up and eaten by Tongas and, on a large scale, by bushpigs (umNyela).
C. glandulosa Schinz 723 Tree. E slope Ndumu Hill in *Acacia nigrescens* Woodland. Bunguzane (1st record for Natal).
C. pyracanthoides Engl. subsp. *pyracanthoides* 78 Shrub. Red Cliffs; Ndumu Hill; western area in woodland.

(99) PTAEROXYLACEAE

- 4157 *Ptaeroxylon obliquum* Eckl. & Zeyher 811 Tree. Mahemane. Common in woodland and thicket. Browsed. Good fire wood.

(100) MELIACEAE

- 4163 *Entandophragma caudatum* (Sprague) Sprague 2657 CJW Tree. One large specimen north of Bunguzane. No young specimens known in the wild. Yellow autumn foliage conspicuous from a great distance (the camp, Ndumu Hill).
 4171 *Turraea obtusifolia* Hochst. 384 Shrub. Ndumu Hill; Mkonjane. Woodland. Browsed.
 4175 *Melia azedarach* L. 878 Tree. Riverine Forests. Monkeys eat flowers and berries (introduced).

- 4193 *Ekebergia capensis* Sparrm. 841 Tree. Usutu Floodplain in forest patches.
- 4195 *Trichilia emetica* Vahl. subsp. *emetica* 824 Tree. Widespread. Sweetly scented flowers. Browsed. Fruits eaten by birds, antelope, monkeys (also eat flower buds) and the Tongas who collect the seeds, soak them, squeeze them, cook and eat as soup (umKhuhlu). The wood is used extensively in the manufacture of household utensils by Tongas, and for making drums.
- (101) MALPIGHIACEAE
- 4219 *Sphedammocarpus pruriens* (A. Juss.) Szyszyl. 478 Climber. Ndumu Hill. Woodland, and thicket.
- 4220 *Acridocarpus natalitius* A. Juss. var. *linearifolius* Launert Scandent shrub. Ulukondo. Sand Forest. Browsed.
- (102) POLYGALACEAE
- 4273 *Polygala amatymbica* Eckl. & Zeyher 112 Herb. E slope Ndumu Hill. Thicket.
- P. senensis* Klotzsch 1558 Herb. Bunguzane; Mahemane pools (1st record for Natal).
- P. sphenoptera* Fresen 126 Herb. Ndumu Hill, woodland.
- P. producta* N.E.Br. 133a Herb. Margins of Pongola Floodplain. Flowers close at night.
- (103) DICHAPETALACEAE
- 4283 *Dichapetalum cymosum* (Hook.) Engl. 890 Herb. Very common on Ndumu Hill. Apparently impervious to fire—is the first to shoot again after a burn. 1671 on Ndumu Hill above Ulukondo are very large communities of very hairy plants.
- (104) EUPHORBIACEAE
- 4297 *Securinega virosa* (Roxb. ex Willd.) Pax & Hoffm. 1279 Shrub. Widespread. Sweetly scented flowers, attract many insects. Birds feed on fruits. Browsed.
- 4299 *Phyllanthus asperulatus* Hutch. 1605 (The status of this species is uncertain) Herb. Mdipine. *Acacia tortilis* Woodland.
- P. burchellii* Muell. Arg. 1033 Herb. Ndumu Hill. Common in woodland. Leaves close at night or on picking.
- P. discoideus* (Baill.) Muell. Arg. 942 KLT E of Pongola Floodplain. Browsed.
- P. flacourtioides* Hutch. 1640 Tree. Pongola Riverine Forest.
- P. maderaspatensis* L. 724 Herb. Ndumu Hill. Very common.
- P. reticulatus* Poir. 838 Shrub. Floodplains. Browsed.
- 4309 *Drypetes arguta* (Muell. Arg.) Hutch. 782 Tree. Ulukondo. Frequent in Sand Forest.
- 4325 *Hymenocardia ulmoides* Oliv. 1410 Tree. Ulukondo. Sand Forest; also occasionally in woodland on Ndumu Hill. Used for making Fonya fishing baskets (thrust baskets).
- 4327 *Antidesma venosum* E. Mey. ex Tul. 573 Tree. Pongola Riverine Forest; Ndumu Hill. Browsed. Monkeys, birds, Tongas eat fruits (umShongi).
- 4343 *Cleistanthus schlechteri* (Pax) Hutch. 781 Tree. Ulukondo. Common in Sand Forest.

- 4345 *Bridelia cathartica* Bertol.f. subsp. *cathartica* 650 Shrub. Floodplains. Browsed. Monkeys eat fruits.
- 4348 *Croton gratissimus* Burch. 865 Tree. Ulukondo. In Sand Forest. Used to make furniture by Tongas.
C. menyhartii Pax 887 Shrub. Bunguzane; widespread and common. Used for Fonya (thrust) fishing baskets.
C. pseudopulchellus Pax 868 Shrub. Ulukondo. Sand Forest.
C. steenkampiana Gerstner 348 Shrub. Ulukondo. Common on edges of Sand Forest.
- 4361 *Caperonia stuhlmannii* Pax 348 Herb. Pongola Floodplain.
- 4407 *Acalypha ecklonii* Baill. 1433 Herb. Pongola Riverine Forest.
A. glabrata Thunb. 738 Shrub. Engabateni. Uncommon. Sand Forest. Used for Fonya (thrust) fishing baskets.
A. indica L. 305 Herb. Ndumu Hill. Woodland; on disturbed ground.
A. petiolaris Hochst. 604 Shrub. Usutu Floodplain.
- 4416 *Tragia incisifolia* Prain 1597 Herb. Mkonjane. *Acacia nigrescens* Woodland.
T. sp. c.f. *T. durbanensis* O. Kuntze 772 Climber. Ndumu Hill. Frequent. Plant raises stinging weals on skin. Browsed.
- 4422 *Dalechampia galpinii* Pax 679 Climber. Mkonjane. *Acacia nigrescens* Woodland in west.
- 4424 *Ricinus communis* L. 1813 Shrub. Floodplains (introduced.)
- 4433 *Jatropha variifolia* Pax 22 Shrub. Very common in Mahemane Thicket.
J. sp. c.f. *J. curcas* L. 466 Tree. Usutu Floodplain. Sweetly scented flowers.
J. sp. 680 Herb. Mkonjane in *Acacia nigrescens* Woodland.
- 4464 *Suregada zanzibarensis* Baill. 1117 Tree. Ulukondo. Sand Forest.
- 4478a *Spirostachys africana* Sond. 1756 EJM Tree. Mahemane. Frequent in pan-edge communities; on boulder beds. Antelope and monkeys eat dried fallen leaves. Stingless bees use these trees extensively for their nests.
- 4483 *Sapium ellipticum* (Hochst.) Pax 1342 Tree. Pongola Riverine Forest.
S. integerrimum (Hochst. ex Krauss) J. Leon 312 Tree. Ulukondo. Sand Forest.
- 4498 *Euphorbia cooperi* N.E.Br. ex Berger var. *cooperi* * Succulent shrub. Abercorn drift. Planted in camp and crocodile farm gardens.
E. geniculata Orteg. 404 Herb. Usutu Riverine Forest.
E. grandicornis Goebel ex N.E.Br. subsp. *grandicornis* 646 Succulent shrub. Mahemane. Thicket, disturbed areas, particularly round old kraal sites between Banzi and Inyamiti pans. Attracts many insects when in flower, especially wasps. Monkeys eat fruits. Thorns raise painful, itchy bump on skin.
E. hirta L. 559 KLT "Common weed on floodplain". (KLT).
E. hypericifolia L. 145 Herb. Pongola Floodplain margins.
E. ingens E.Mey. ex Boiss. Succulent tree. Mahemane clearing. Widespread. Monkeys eat flowers and fruits.
E. knuthii Pax 291 Succulent. Mahemane. Common, widespread.
E. pseudotuberosa Pax 121 Bulb. E slope Ndumu Hill. Uncommon. In *Acacia nigrescens* Thicket.
E. tirucalli L. 66 Succulent shrub. Ulukondo Sand Forest. Black rhino browse. Monkeys eat fruits.

Euphorbia triangularis Desf. * Succulent shrub. Abercorn drift, in Lebombo foothills just outside W boundary. Planted in gardens.

- 4500 *Synadenium cupulare* (Boiss.) L. C. Wheeler 1048 KLT Shrub. Ulukondo. Sand Forest and thicket. Sap causes severe irritation, raising blisters on skin and causing headache and nausea.
- 4503 *Monadenium lugardae* N.E.Br. 67 Succulent. Mahemane—infrequent fairly large communities.

(107) ANACARDIACEAE

- 4545 *Mangifera indica* L. Tree. Frequent, very large specimens in Riverine Forests—sometimes large communities. Eaten by man and monkeys (introduced).
- 4558 *Sclerocarya caffra* Sond. 273 Tree. Ndumu Hill. Common locally in woodland; occasionally scattered in woodland elsewhere. Spring leaves appear with the flowers. Flowers cup-shaped when first open, petals fold back later, do not close at night. Many insects, especially bees, attracted to flowers. Fruits drop when green, ripen on ground. Eaten by animals and man (mGanu). A beer is brewed from the fruits by the Tongas. Nuts from the hard seed are used as food by the Tongas (uMongo, small but delicious, like a walnut). Bark of the trees is used to dye fish nets. Leaves browsed by antelope. Large caterpillars, found in quantities on *S. caffra* in mid-summer, are collected and eaten by the Tongas. A large borer grub is also collected to eat, by tapping the bark of the tree until a hollow sound indicates a borer's hole. Trees can be killed by infestations of this large insect. When in green fruit, some trees become infested by caterpillars which devour all the leaves off the tree, and cover the entire tree, trunk and branches, with fine, strong, silky web. This does not apparently adversely affect the tree, which produces new leaves and soon returns to normal again. It would be useful to have the correct names of the caterpillars, borers and moths associated with this tree.
- 4563 *Lannea stuhlmannii* (Engl.) Engl. 294 Tree. Ndumu Hill. Woodland. Fruits eaten by monkeys and Tongas (umGanunkomo). Bark of trees used to dye fish nets.
- 4589 *Ozoroa obovata* (Oliv.) R. & A. Fernandes var. *obovata* 378 Tree. Ndumu Hill. Woodland. Browsed.
- 4594 *Rhus fraseri* Schonl. 1230 Shrub. Usutu Floodplain.
R. guenzii Sond. var. *spinescens* (Diels) R. & A. Fernandes 835 Shrub. Widespread. Browsed by nyala. Birds feed on fruits which are also eaten by Tongas (umPhondo).
R. sp. 1044 Shrub. E slope Ndumu Hill. Frequent.

(109) CELASTRACEAE (Incl. Hippocrataceae)

- 4626 *Maytenus heterophylla* (Eckl. & Zeyher) N. Robson 886 Shrub. Widespread. Flowers sweetly, sometimes unpleasantly, scented. Blooms up to four times a season. Heavily browsed.
 1646—Ndumu Hill—this form common on hill; leaves grey, black striated bark, main stem clearly formed and tree-like rather than shrub-like. A very variable species.
M. nemorosa (Eckl. & Zeyher) Marais 1431 Shrub. Mdipline. Usutu Floodplain.
M. senegalensis (Lam.) Exell 825 Shrub. Ndumu Hill. Woodland. Browsed. Monkey eat leaves and shoots.

4628 *Putterlickia verrucosa* (E. Mey. ex Sond.) Szyszyl. 1415 Shrub. E of Pongola Floodplain.

464 *Cassine aethiopica* Thunb. 675 Tree. Ndumu Hill, scattered in woodland. Browsed. Fruits eaten by Tongas (umGunguluzampunzi).

C. transvaalensis (B. Davy) Codd 799 Tree. Mahemane. Browsed.

4661 *Hippocratea africana* (Willd.) Loes. var. *richardiana* (Cambess.) N. Robson 881 Climber. Mahemane. Thicket.

4662 *Salacia kraussii* (Harv.) Harv. 889 Shrub. Ndumu Hill, woodland. Very common. Browsed. Fruits eaten by animals and man (amaBonsi). Not affected by fire.

S. leptoclada Tul. 756 Shrub. Ulukondo. Sand Forest. Fruits eaten by Tongas (uHlangahomo). Browsed.

(110) ICACINACEAE

4709 *Pyrenacantha kaurabassana* Baill. 128 Climber, with large swollen underground root. Woodland. Fruits eaten by Tongas (inZema).

(111) SAPINDACEAE

4726 *Cardiospermum halicababum* L. 402 Climber. Common on floodplains.

4734 *Allophylus decipiens* (Sond.) Radlk. 1417 Shrub. Riverine Forests. Scented flowers.

4746 *Deinbollia oblongifolia* (E. Mey.) Radlk. 594 Shrub. Widespread, not common. Browsed.

4769 *Haplocoelum gallense* (Engl.) Radlk. 735 Tree. Ulukondo, Sand Forest.

4784 *Pappea capensis* Eckl. & Zeyher 1435 Tree. Mahemane. Browsed. Fruits eaten by animals and man (umQuokwane).

(115) RHAMNACEAE

4861 *Ziziphus mucronata* Willd. 383 Tree. Ndumu Hill. Woodland. Browsed. Bark, leaves and fruits are eaten by many animals. Tongas eat the berries (umPhafa).

4868 *Berchemia discolor* (Klotzsch) Hemsl. 416 KLT E of Pongola Floodplain. Monkeys eat the fruits.

B. zeyheri (Sond.) Grubov 388 Tree. Ndumu Hill. Woodland. Many insects visit flowers, especially bees. Heavily browsed. Fruits eaten by birds, monkeys, antelope and people (umNeyi).

(116) HETEROPYXIDACEAE

4908a *Heteropyxis natalensis* Harv. 873 KLT Paphekulu stream. Drainage line in west.

(117) VITACEAE

4917 *Rhoicissus digitata* (L.f.) Gilg & Brandt 922 Climber. Ndumu Hill. Woodland. Browsed.

R. tridentata (L.f.) Wild & Drummond 1274 Climber. Mahemane Thicket. Browsed.

4918 *Cissus quadrangularis* L. 81 Succulent climber. Ndumu Hill, Mahemane. Common in thicket.

C. rotundifolia (Forsk.) Vahl 114 Succulent climber. Ndumu Hill. Frequent in woodland. Browsed by nyala.

- 4918a *Cyphostemma barbosae* Wild & Drummond 677 Succulent herb with large swollen root. Mkonjane. Not common.
C. cirrhosum (Thunb.) Desc. ex Wild & Drummond subsp. *transvaalense* (Szy-szyl.) Wild & Drummond 1240 Succulent climber. Mahemane Thicket.
C. subciliatum (Bak.) Desc. ex Wild & Drummond 451 Climber. Riverine Forest and Floodplain margins.

(118) TILIACEAE

- 4953 *Corchorus asplenifolius* Burch. 1272 Herb. Mahemane Thicket.
C. junodii (Schinz) N.E.Br. 894 Herb. Ndumu Hill.
- 4966 *Grewia bicolor* Juss. 807 Shrub. Mahemane. Widespread. Browsed. Fruits eaten by birds and Tongas (uSipane).
G. caffra Meisn. 744 Shrub. Widespread. Browsed. Birds, monkeys and people eat the fruits (iPhata). Angled stems used for making traps (for monkeys and crocodiles etc.).
G. flava DC. 1066a Shrub. Ndumu Hill. Woodland.
G. microthyrsa K. Schum. ex Burret 734 Shrub. Ulukondo. Sand Forest. Browsed. Birds, monkeys, Tongas eat fruits (uMunyuane).
G. monticola Sond. 330 Tree. Ndumu Hill. Woodland.
G. occidentalis L. 274 Shrub. Mahemane near Banzi pan. Browsed.
G. subspathulata N.E. Br. 410 KLT.
G. villosa Willd. 668 Shrub. Mkonjane. *Acacia nigrescens* Woodland.
- 4975 *Triumfetta pentandra* A. Rich. 507 Herb. Ndumu Hill. Woodland.

(119) MALVACEAE

- 4983 *Abutilon austro-africanum* Hochr. 83a Herb. Pongola Floodplain margin.
A. englerianum Ulbr. 148 Herb. Ndumu Hill. Woodland.
A. grandiflorum G. Don 1359 Herb. Floodplains.
A. guineense (Schum.) Bak.f. & Exell 670 Herb. Mkonjane. *Acacia nigrescens* Woodland. Flowers remain open all day.
- 4995 *Malvastrum coromandelianum* (L.) Garcke 758 Herb. Usutu Floodplain.
- 4998 *Sida cordifolia* L. 745 Herb. Ndumu Hill. Woodland. Flowers open early morning, close midday.
S. dregei Burtt Davy 144 Herb. Pongola Floodplain. Flowers close at midday.
S. rhombifolia L. 399 Shrub. Floodplains.
- 5007 *Pavonia leptocalyx* (Sond.) Ulbr. 751 Herb. Ulukondo. Sand Forest.
P. patens (Andr.) Chiov. 751 Herb. Mahemane. Thicket.
- 5013 *Hibiscus calyphyllus* Cav. 1314 Shrub. Floodplain margins. Widespread. Well browsed.
H. cannabinus L. 472 Herb. Pongola Floodplain. Flowers close midday.
H. dongolensis Del. 539 Shrub. Mkonjane.
H. micranthus L.f. 110 Herb. Pongola Floodplain margins. Flowers open white, turn red later.
H. palmatus Forsk. 354 Herb. Near Banzi pan, in thicket.
H. pusillus Thunb. 1006 Herb. Ndumu Hill. Woodland; fairly widespread. Flowers can be yellow or mauve and usually open after rain or storm; open early morning, close in afternoon.
H. sabiensis Exell 110a Herb. Ulukondo. Sand Forest.
H. schinzii Guerke 746 Herb. Ndumu Hill. Observed in and near the main camp.

- Hibiscus surattensis* L. 458 Scandent shrub. Usutu Floodplain. Flowers close in afternoon.
- H. trionum* L. 1462 Herb. Pongola Floodplain margins.
- H. vitifolius* L. subsp. *vulgaris* Brenan & Exell 471 Shrub. Pongola Floodplain margins. Flowers close in evening.
- 5018 *Thespesia acutiloba* (Bak.f.) Exell & Mendonca 31 Tree. Ndumu Hill; Pongola Riverine Forest. Flowers close mid-afternoon. Fruits eaten by birds. Browsed by antelope.
- 5019 *Cienfuegosia hildebrandtii* Garcke 1390 Shrub. Mkonjane. *Acacia nigrescens* Woodland. Heavily browsed.
- 5020 *Gossypium herbaceum* L. var. *africanum* (Watt) Hutch. & Ghose 1488 Scandent shrub. Pongola Floodplain margins.
- (120) STERCULIACEAE
- 5047 *Melhantha didyma* Eckl. & Zeyher 1033 Herb. Ndumu Hill. Woodland. Flowers open in afternoon, close at night. Scented.
- M. forbesii* Planch. ex Mast. 1296 Herb. Common, west of Shokwe. Woodland.
- 5053 *Dombeya rotundifolia* (Hochst.) Planch. var. *rotundifolia* 830 Tree. Usutu Floodplain. Uncommon. Sweetly scented flowers.
- 5056 *Hermannia micropetala* Harv. 498 Herb. Ndumu Hill. Woodland.
- 5059 *Waltheria indica* L. 1407 Shrub. Pongola Floodplain margins.
- 5083 *Sterculia rogersii* N.E.Br. 23 Tree. Common on Ndumu Hill. Woodland. Fruits resemble a peach, with the velvety pink/grey/green bloom. Seeds eaten by birds and Tongas, but hairs in the pod cause itchy irritation to skin (nKhumphenk-huphe). Transplants easily from truncheons. Browsed.
- 5091 *Cola microcarpa* Brenan 867 Tree. Ulukondo. Sand Forest.
- (121) OCHNACEAE
- 5112 *Ochna arborea* Burch. ex DC. 697 Shrub. Ndumu Hill. Woodland. No leaves with flowers (scented). Fruits orange rather than red; eaten by monkeys.
- O. natalitia* (Meisn.) Walp. 135b Shrub. Ndumu Hill. Woodland. Flowers appear with leaves, scented. New leaves bright coppery red. Very pretty bright deep-pink galls on this plant are conspicuous. Browsed.
- O. serrulata* (Hochst.) Walp. 14 ICP
- (122) CLUSIACEAE (nom. alt. Guttiferae)
- 5199 *Garcinia livingstonei* T.And 711 Tree. Ndumu Hill. Woodland. Fruits appear on old wood, very delicious, eaten by animals and man (umPhimbu). Browsed.
- (125) VIOLACEAE
- 5271 *Hybanthus enneaspermus* (L.) F. Muell. var. *serratus* Engl. 111 Herb. Pongola Floodplain.
- (126) FLACOURTIACEAE
- 5284 *Oncoba spinosa* Forsk. 1065 Tree. Riverine Forests, occasional on drainage lines.

5284a *Xylothea kraussiana* Hochst. var. *kraussiana* 422 Shrub. Ndumu Hill. In thickets in woodland. Flowers scented. Petals drop after four days. Fruits split into segments to expose red and black sticky seeds, eaten by birds, Tongas. Browsed.

5304 *Scolopia zeyheri* (Nees) Szyszyl. 1422 Shrub. Pongola Floodplain margins.

5328 *Dovyalis caffra* (Hook.f. & Harv.) Hook.f. 763 Tree. Mahemane. Widespread. Many insects attracted to flowers. Fruits eaten by animals and man. Browsed (umQokolo).

D. longispina (Harv.) Warb. 286 Shrub. Near Shokwe pan, in thicket. Birds, Tongas eat the fruits (umNyazuma).

(128) PASSIFLORACEAE

5370 *Adenia hastata* (Harv.) Schinz 1156 Climber. Mahemane Thicket.

A. senensis (Kl.) Engl. 862 Climber. Ulukondo. Sand Forest.

(131) CACTACEAE

Opuntia ficus-indica L. Mill. 78 TBO Succulent weed. NRC house surrounds and scattered in the reserve (introduced).

O. megacantha NRC house and scattered elsewhere in the reserve, despite attempts to eradicate both species (introduced).

(133) THYMELACACEAE

5435a *Lasiosiphon capitatus* (L.f.) Burtt Davy 667 Shrub. S boundary in the west, *Acacia nigrescens* Woodland.

5442 *Synaptolepis kirkii* Oliv. 109 Climber. Ndumu Hill. Forms occasional thickets. Scented.

(134) LYTHRACEAE

5480 *Galpinia transvaalica* N.E.Br. 366 Tree. On slopes of Ndumu Hill. Scented flowers attractive to insects. Flowers only last a few days but make the tree conspicuous for that brief time.

(137) COMBRETACEAE

5538 *Combretum acutifolium* Exell 5362 EJM Tree. Ulukondo. Locally common. Sand Forest.

C. apiculatum Sond. subsp. *apiculatum* 786 Tree. Ulukondo. Sand Forest.

C. collinum Fresen. subsp. *suluense* (Engl. & Diels) Okafor 1116 Tree. Ulukondo; Ndumu Hill. Sand Forest, woodland. Flowers attract many insects.

C. hereoense Schinz 69 Tree. Common in *Acacia nigrescens* Woodland. Browsed.

C. imberbe Wawra 1066 Tree. Scattered in *Acacia nigrescens* Woodland in west and on margins of Ndumu Hill.

C. kraussii Hochst. 1665 Tree. Ulukondo. Sand Forest.

C. microphyllum Klotzsch. 828 Climber. Floodplains. Browsed. Climber to tops of trees where it flowers and fruits prolifically.

C. molle R.Br. ex Don 919 Tree. Ndumu Hill. Woodland. Browsed.

C. zeyheri Sond. 676 Tree. Ndumu Hill. Woodland.

5539 *Pteleopsis myrtifolia* (Laws.) Engl. & Diels 789 Tree. Ulukondo. Browsed. Common in Sand Forest.

5541 *Quisqualis parviflora* Gerrard ex Harv. 1100 Climber. Ulukondo. Common in Sand Forest.

5544 *Terminalia phanerophlebia* Engl. & Diels 100 TPD Paphekulu stream. Drainage line in SW corner of reserve.
T. sericea Burch. 419 Tree. Common, Ndumu Hill. Woodland. Unpleasantly scented flowers, attracts many insects. Browsed. Very hard, ant-resistant wood; makes excellent fire-wood.

(138) MYRTACEAE

5578 *Eugenia mossambicensis* Amshoff 803 Shrub. Common on Ndumu Hill. Woodland. Forms thickets. Not affected by fire. Browsed. Flowers scented, attract many insects. Fruits eaten by animals and Tongas (iNontsane).

5583 *Syzygium guineense* (Willd.) DC. 2029 CJW Tree. Floodplains. Browsed. Monkeys eat flower buds, flowers, fruit. Tongas eat fruits (umDoni-wamanzi).

Psidium guajava L. Tree. Large groves along river banks (introduced).

(140) ONAGRACEAE

5793 *Ludwigia octovalvis* (Jacq.) Raven subsp. *octovalvis* 493 Herb. Floodplains. At Banzi pan it grows in the raft of floating vegetation. Flowers open and close in the morning.

L. stolonifera (Guill. & Perr.) Raven 659 Semi-emergent aquatic; Pongola Floodplain. On pans and seasonal pools. Flowers close in early afternoon.

(141) TRAPACEAE

5829 *Trapa natans* L. var. *bispinosa* (Roxb.) Makino 320 Aquatic. Common in Banzi pan. Spiny fruits collected, taken home and dried, then cracked open and eaten by Tongas (iniYva). Food for waterfowl too.

(144) ARALIACEAE

5872 *Cussonia arenicola* Strey 65 Shrub. Ulukondo. Sand Forest.

(145) APIACEAE (nom. alt. Umbelliferae)

5894 *Centella asiatica* (L.) Urban 459 Herb. Floodplains.

(150) PLUMBAGINACEAE

6343 *Plumbago zeylanica* L. 599 Shrub. Usutu Floodplain. Infrequent. Faintly scented. Flowers close at night, re-open next day.

(151) SAPOTACEAE

6368 *Sideroxylon inerme* L. 879 Tree. Margins of floodplains; Mahemane; drainage lines. Fruits eaten by birds, monkeys.

6386a *Manilkara discolor* (Sond.) J. H. Hemsl. 1831 Tree. Ulukondo. Sand Forest. Tongas eat fruits (umNweba).

M. mochisia (Bak.) Dubard. 1054 Tree. Ndumu Hill; Mahemane. Common in thicket. Flowers without leaves, heavy honey scent which attracts many insects. Browsed. Birds, monkeys. Tongas eat fruits (umNqambo).

(152) EBENACEAE

6404 *Euclea crispa* (Thunb.) Guerke var. *crispa* 336 Shrub. Ndumu Hill. Common shrub in woodland. Monkeys, Tongas eat fruits.

E. divinorum Hiern 844 Tree. Mahemane. Common. Scented flowers. Browsed. Fruits eaten by birds, monkeys and Tongas (umHlangula).

- Euclea natalensis* A.DC. 1404 Tree. E of Pongola Floodplain.
E. schimperi (A.DC.) Dandy var. *daphnoides* (Hiern) de Winter 767 Tree. Mahemane Thicket. Common. Browsed.
E. undulata Thunb. var. *myrtina* (Burch.) Hiern 1129 Tree. Mahemane. Scented, many insects. Fruits eaten by monkeys.
E. undulata Thunb. var. *undulata* 766 Tree. Mahemane Thicket. Scented. Monkeys eat fruits.
- 6406 *Diospyros galpinii* (Hiern) de Winter 768 Herb. Ndumu Hill. Woodland.
D. lycioides Desf. subsp. *guerkei* (Kuntze) de Winter 651 Shrub. Ndumu Hill. Woodland. Forms small thickets. Citrus-scented flowers.
D. villosa (L.) de Winter 1186 Climber. Mahemane. Common in thicket.
- (153) OLEACEAE
- 6440 *Jasminum breviflorum* Harv. ex C.H.Wr. 1025 Climber. Ndumu Hill. Woodland. Very strong, rather unpleasant scent.
J. fluminense Vell. 1192 Climber. Pongola Floodplain margins. Common. Flowers heavily scented, close at night to open again next day. Browsed.
J. stenolobum Rolfe 124 Scandent shrub. Ndumu Hill. Woodland. Scented. Browsed.
J. streptopus E. Mey. var. *transvaalensis* (S. Moore) Verdoorn 774 Climber. Ulukondo. Sand Forest.
- (154) SALVADORACEAE
- 6444 *Azima tetracantha* Lam. 874 Shrub. Widespread in thicket, common. Browsed.
- 6446 *Salvadora angustifolia* Turrill var. *australis* (Schweick.) Verdoorn 837 Tree. Mahemane Thicket. Foul-smelling flowers.
- (155) LOGANIACEAE
- 6460 *Strychnos decussata* (Pappe) Gilg 752 Tree. Mahemane Thicket. Browsed.
S. madagascariensis Poir. 713 Tree. Ndumu Hill. Woodland. Browsed. Forms occasional low thickets. Monkeys eat fruits. Tongas collect fruits, grind up, dry, then add sugar and eat (mKwakwa).
S. spinosa Lam. 793 Tree. Ndumu Hill. Woodland. Common. Browsed. Scented flowers. Fruits eaten by animals and man (Mahlala). In dry seasons antelope congregate around these trees, scarcely moving, whilst feeding off the fruits.
1122, 792: Ulukondo plants different—warty fruits, large leathery leaves.
1159: Bunguzane plants also look quite different.
S. usambarensis Gilg 1681 Tree. Ulukondo. Sand Forest.
- 6469 *Nuxia oppositifolia* (Hochst.) Benth. 803 KLT Usutu Riverine Forest.
- (156) GENTIANACEAE
- 6484 *Enicostemma hyssopifolium* (Willd.) Verdoorn 1343 Herb. Usutu Floodplain.
- 6545 *Nymphoides* sp. c.f. *N. rautenannii* N.E.Br. 1578 Aquatic. Mahemane pools. Uncommon, found in shallow water of seasonal pools.
- (157) APOCYNACEAE
- 6558 *Acokanthera oppositifolia* (Lam.) L. E. Codd 1151 Shrub. Mahemane Thicket.
- 6559 *Carissa bispinosa* (L.) Desf. ex Brenan var. *acuminata* (E. Mey.) Codd 70 Shrub. Mahemane Thicket. Heavily scented flowers. Browsed. Fruits eaten by birds, monkeys and Tongas.

- Carissa tetramera* (Sacleux) Stapf 518 Shrub. Mahemane Thicket. Very strongly scented—fills the air on hot humid summer mornings. Browsed. Fruits eaten by birds, monkeys, Tongas (uQondo).
- 6562 *Landolphia kirkii* Dyer 797 Climber. Ndumu Hill. Very common in thicket in woodland. Eaten by animals and Tongas (amaBungwa).
L. petersiana (Kl.) Dyer 253 Climber. Ndumu Hill. Woodland. Heavily scented flowers fill the air for the few days of full flowering. Cover entire tree. Flowers drop after a day. Spectacular sight and scent. Monkeys, Tongas eat the fruits.
- 6603 *Tabernaemontana elegans* Stapf 1193 Tree. Floodplains. Sweetly scented flowers. Browsed. Monkeys eat leaves, flower buds, flowers, fruit. Tongas eat fruit (umKashlu). White sap used as a bird lime by young boys when trapping birds.
- 6619 *Rauvolfia caffra* Sond. 876 Tree. Riverine Forests. Scented flowers. Browsed. Monkeys eat leaves, flower buds, flowers, fruit. Tongas grind up bark and leaves, soak, then drink liquid to alleviate 'fever' (umKhahluvungu).
- 6680 *Adenium obesum* (Forsk.) Roem. & Schult. var. *multiflorum* (Klotzsch) Codd 637 Succulent. Widespread. Large specimens confined to thicket now, due to pressure of browsing animals.
- 6681 *Pachypodium saundersii* N.E.Br. * Succulent. Abercorn drift road, in foothills of Lebombo west of reserve. Planted in gardens.
- 6688 *Strophanthus gerrardii* Stapf 64 Climber. Ulukondo; between Inyamiti and Banzi pans. Sand Forest and thicket. Stem thickens to produce corky-woody triangular shaped bark.
S. luteolus L. E. Codd 27 Climber. Ulukondo; S bank Inyamiti. Sand Forest, thicket. Flowers open for days before dropping, scented.
- 6689 *Wrightia natalensis* Stapf 71 Tree. Ulukondo; Mahemane Thicket. Sand Forest. Scented flowers. Browsed. Used for spear shafts.
- (158) PERIPLOCACEAE
- 6730 *Tacazzea apiculata* Oliv. 547 KLT Pongola Riverine Forest.
- 6740 *Cryptolepis obtusa* N.E.Br. 489 Climber. Usutu Riverine Forest.
- 6741 *Stomatostemma monteiroae* (Oliv.) N.E.Br. 614 Climber. Mahemane. Very common in thicket.
- 6747 *Raphionacme flanaganii* Schltr. 885 Climber. Mahemane Thicket.
- (159) ASCLEPIADACEAE
- 6778 *Schizoglossum garcianum* Schltr. ex descr. 122 Herb. Ndumu Hill, woodland.
- 6791 *Asclepias fruticosa* L. 1275 Herb. Mahemane Thicket.
A. physocarpa (E. Mey.) Schltr. 1814 Herb. Pongola Floodplain. Has proliferated in recent years to become very common, forming fields.
- 6810 *Pentarrhinum insipidum* E. Mey. 461 Climber. Uncommon on Ndumu Hill.
- 6834 *Cynanchum mossambicense* K. Schum. 533 Climber. Uncommon on Ndumu Hill. Woodland.

- 6849 *Sarcostemma viminalis* (L.) R.Br. 55 Succulent climber. Common and widespread. Flowers have attractive scent. Browsed by animals. Tongas eat green fruits and new shoots (umPelepele).
- 6860 *Secamone delagoensis* Schltr. 791 Climber. Ulukondo. Sand Forest. Flowers heavily scented.
S. parvifolia (Oliv.) Bullock 317 Climber. Ndumu Hill. Woodland. Very strong honey-like scent. Browsed.
- 6874 *Ceropegia monteiroae* Hook. 510 Succulent climber. Ulukondo. Sand Forest (1st record for Natal).
C. plicata E. A. Bruce 460 Succulent climber. Ndumu Hill, widespread but not common. Flowers drop after a couple of days.
C. rendallii N.E.Br. 422 Succulent climber. Ndumu Hill. Woodland.
C. sandersonii Hook.f. 510 Succulent climber. Ulukondo. Sand Forest. Flowers are scented, droop after a couple of days. Stingless bees feed off flowers.
C. stapeliiformis Haw. var. *serpentina* (Bruce) H. Huber 423 Succulent climber. Ulukondo. Sand Forest.
C. stapeliiformis Haw. var.? 424 Succulent climber. Ulukondo. Sand Forest.
- 6875 *Riocrexia torulosa* (E. Mey.) Decne. 456 Climber. Usutu Floodplain. Profusion of this plant in reedbeds on edge of forest. Heavy wild-honey scent.
- 6885 *Stapelia gigantea* N.E.Br. 8 JVH Succulent. Mahemane. Widespread. Browsed by antelope.
S. longidens N.E.Br. 505 Succulent. Ndumu Hill. Woodland.
- 6887 *Huernia hystrix* N.E.Br. 101 Succulent. Mahemane Thicket.
H. zebrina N.E.Br. 283 Succulent. Ndumu Hill. Woodland.
- 6891 *Gymnema sylvestre* (Retz.) Schultes 457 Climber. Usutu Floodplain. Flowers scented, attract many butterflies.
- 6899 *Tylophora lycioides* Decne. 1209 Climber. Usutu Floodplain.
- 6911 *Marsdenia floribunda* (E. Mey.) N.E.Br. 77 Climber. Mahemane Thicket.
- 6917 *Pergularia daemia* (Forsk.) Chiov. 496 Climber. Common on Ndumu Hill. Woodland. Flowers open in late afternoon.
- (160) CONVULVULACEAE
- 6973 *Evolvulus alsinoides* (L.) L. var. *linifolius* (L.) Bak. 1308 Herb. Mahemane Thicket.
E. nummularis L. 761 Herb. Banzi pan shoreline. Small prostrate plant that creates a carpet of green over the dry black clay.
- 6978 *Seddera capensis* (E. Mey. ex Choisy) Hall. 678 Herb. S boundary in west.
S. suffruticosa (Schinz) Hall.f. 430 Herb. Mahemane Thicket.
- 6991 *Jacquemontia tamnifolia* (L.) Griseb. 517 Climber. Pongola Floodplain margins. Flowers close mid-morning.
- 6993 *Convolvulus farinosus* L. 640 Climber. Floodplains.
- 6995 *Hewittea sublobata* (L.f.) Kuntze 1282 Climber. River-banks.
- 6997 *Merremia palmata* Hall.f. 88 Climber. Ndumu Hill. Woodland.
M. tridentata (L.) Hall.f. subsp. *angustifolia* (Jacq.) Ooststr. 1560 Climber. Mahemane Thicket.

- 7003 *Ipomoea albivenia* (Lindl.) Sweet 40 Climber. Ndumu Hill. Flowers open at night, close at midday—scented. Flowers and leaves attacked by caterpillars. Large underground rootstock. Seeds wrapped in 'cotton wool'; when pods open to reveal them, creeper appears to be in flower again. Blooms prolifically for 3 to 4 weeks. Leafless in winter.
- I. bolusiana* Schinz 1666 Climber. Ndumu Hill. Woodland.
- I. cairica* (L.) Sweet 770 Climber. Ulukondo; Pongola river banks; Usutu Riverine Forest. Very common. Flowers close mid-afternoon. Monkeys eat shoots, flower buds, flowers, fruits. Hippo observed eating bunches of the creeper.
- I. coptica* (L.) Roth ex Roem. & Schult. 1562 Climber. Seepage lines on Ndumu Hill.
- I. digitata* L. var. *digitata* 324 Climber. Pongola Riverine Forest. Flowers up to height of 20 m, rooted in deep shade, large rootstock.
- I. digitata* L. var. *eriosperma* (P. Beauv.) Rendle 323 Climber. Pongola Riverine Forest. Flowers up to height of 20 m. Woody main stem. Large rootstock. Flowers open early morning, close early afternoon.
- I. lapathifolia* Hall.f. 1567 Climber. Balemhlanga. Drainage line in west (1st record for Natal).
- I. magnusiana* Schinz 776 Climber. Ndumu Hill. Flowers close at midday.
- I. obscura* (L.) Ker-Gawl. var. *fragilis* (Choisy) A. Meeuse 1233 Climber. Ndumu Hill. Woodland.
- I. pellita* Hall.f. 143 Climber. E slope Ndumu Hill.
- I. sinensis* (Desr.) Choisy subsp. *blepharosepala* (Hochst. ex A. Rich.) Verdc. 1617 Climber. S boundary in west.
- I. wightii* (Wall.) Choisy 490 Climber. Usutu Floodplain. Flowers open early, close midday.

(161) BORAGINACEAE

- 7038 *Cordia caffra* Sond. 1246 Tree. Usutu Floodplain. Fruits eaten by Tongas (iLovu amakhulu).
- C. ovalis* R.Br. 814 Shrub. Mahemane, common and widespread. Fruits eaten by Tongas (iLovu mcani).
- 7043 *Ehretia amoena* Klotzsch 301 Tree. Pongola Floodplain margins. Flowers sweetly scented, attracting many insects. Browsed. Birds, monkeys, Tongas eat fruits (umHlele amakhulu).
- E. rigida* (Thunb.) Druce 369 Shrub. Ndumu Hill; Mahemane. Widespread. Flowers sometimes scented. Leaves very variable in size and shape. Much browsed. Fruits eaten by birds, monkeys, Tongas (umHlele). Used for making Fonya (thrust) fishing baskets.
- 7052 *Heliotropium ciliatum* Kaplan 138b Herb. Ndumu Hill. Woodland.
- H. curassavicum* L. 822 Herb. Inyamiti pan.
- H. indicum* L. 829 Herb. Floodplains. Eaten as 'spinach' (imifino ubhoyo) by Tongas.
- H. ovalifolium* Forsk. 581 Herb. Usutu Floodplain.
- H. steudneri* Vatke 665 Herb. Mahemane Thicket.
- 7056 *Trichodesma zeylanicum* (Burm.f.) R.Br. 524 Herb. Usutu Floodplain. S boundary fence near Agate hill.

(162) VERBENACEAE

- 7138 *Verbena bonariensis* L. 403 Shrub. Floodplains (introduced).

- 7144 *Lantana camara* L. 227 Scandent shrub. W of Shokwe (introduced).
L. rugosa Thunb. 1491 Shrub. Ndumu Hill. Fruits eaten by birds, monkeys
 and Tongas (umKukutwane). Aromatic leaves and stems.
- 7145a *Phyla nodiflora* (L.) Greene 425 Herb. Inyamiti causeway at Pongola channel.
 Floodplains.
- 7148 *Chascanum hederaceum* (Sond.) Moldenke var. *natalense* (H. H. W. Pearson)
 Moldenke 1807 Herb. Ndumu Hill. Woodland.
C. schlechteri (Guerke) Moldenke 205 Herb. Ndumu Hill; Agate hill, south
 boundary. Flowers close at night to open again next day.
- 7153 *Priva cordifolia* (L.f.) Druce var. *abyssinica* (Jaub. & Spach) Moldenke
 759 Herb. Widespread and common. Leaves cling together. Sticky clinging
 fruits.
- 7185 *Premna mooiensis* (H. H. W. Pearson) Pieper 1303 Tree. Mahemane; *Acacia*
tortilis Woodland. Aromatic leaves.
- 7186 *Vitex patula* E. A. Bruce 780 Shrub. Common in Ulukondo. Sand Forest.
 Browsed. Tongas eat fruits (imBendula).
V. harveyana H. H. W. Pearson 118 Shrub. Paphekulu. Drainage line in west.
 Scented. Fruits eaten by birds, monkeys, Tongas (imBendula).
- 7191 *Clerodendron glabrum* E. Mey. 1336 Shrub. Floodplains. Very variable
 leaves. Browsed. Scented. Flowers attractive to butterflies.
- 7192 *Holmskioldia tettensis* (Klotzsch) Vatke 729 Shrub. Lebombo foothills—
 planted in gardens.
- (163) LAMIACEAE (nom. alt. Labiateae)
- 7236 *Acrotome hispida* Benth. 848 Herb. Ulukondo. Sand Forest.
- 7264 *Leonotis nepetifolia* (L.) Ait.f. 597 Herb. Usutu Floodplain.
- 7268 *Leucas glabrata* (Vahl) R.Br. ex Benth. 50 Herb. Common, widespread,
 browsed.
- 7281 *Stachys spathulata* Burch. ex Benth. 522 Herb. Usutu Floodplain.
- 7342 *Hyptis pectinata* (L.) Poit. 601 Herb. Usutu Floodplain. Common. Also com-
 mon in disturbed areas E of Pongola Floodplain.
- 7350 *Plectranthus amboinicus* (Lour.) Spreng. 107 Herb. Mahemane. Leaves aro-
 matic.
P. cylindraceus Hochst. ex Benth. 521 Succulent herb. S bank Inyamiti pan.
 Thicket.
P. neochilus Schltr. 45 Slightly succulent herb. Mahemane. Very common.
 Aromatic, sticky to touch.
P. spicatus E. Mey. ex Benth. 626 Slightly succulent herb. Mahemane
 Thicket.
P. vagatus (E. A. Bruce) L. E. Codd 483 Mahemane Thicket.
P. verticillatus (L.f.) Druce 519 Succulent herb. Ulukondo. Sand Forest.
- 7357 *Hoslundia opposita* Vahl var. *decumbens* (Benth.) Bak. 154 Herb. Ndumu
 Hill. Browsed. Fruits eaten by animals and Tongas, delicious (uYaweyawe).
- 7357a *Iboza riparia* (Hochst.) N.E.Br. * Succulent shrub. Lebombo foothills, planted
 in gardens.

- 7364 *Basilicum polystachyon* (L.) Moench 484 Herb. Floodplains.
 7366 *Ocimum canum* Sims 343 Herb. Mahemane Thicket.
O. urticifolium Roth 1298 Herb. Near Shokwe pan.
 7366a *Becium obovatum* (E. Mey. ex Benth.) N.E.Br. 116 Herb. Ndumu Hill.
 Woodland.
 7367 *Orthosiphon suffrutescens* (Thonning) J. K. Morton 123 Herb. Ndumu Hill,
 woodland.

(164) SOLANACEAE

- 7377 *Nicandra physaloides* Gaertn. 592 Herb. Ndumu Hill, Usutu Floodplain.
 7379 *Lycium acutifolium* E. Mey. 1140 Shrub. Mahemane Thicket. Browsed.
L. oxycladum Miers. 3149 CJW Shrub. NW margin of Inyamiti.
 7400 *Withania somnifera* (L.) Dunal 1187 Shrub. Usutu Floodplain. On disturbed
 ground.
 7407 *Solanum capense* L. 142 Climber. Frequent and widespread.
S. coccineum Jacq. 1387 Shrub. Mahemane Thicket.
S. incanum L. 816 Shrub. Inyamiti pan margins.
S. nigrum L. sens. lat. 309 Herb. Ndumu Hill. Woodland.
S. panduraeforme E. Mey. 1334 Shrub. Very common, floodplains, Ndumu
 Hill. Leaves, fruits browsed.

(165) SCROPHULARIACEAE

- 7517 *Manulea parviflora* Benth. 596 Herb. Usutu Floodplain. Uncommon.
 7519 *Sutera brunnea* Hiern var. *macrophylla* Hiern 227a Herb. F. slope Ndumu
 Hill, *Acacia nigrescens* Thicket.
 7564 *Ilysanthes dubia* (L.) Bernh. 1557 Herb. Mahemane pools, in shallow water.
 7597a *Alectra kirkii* Hemsl. 525 Herb. Usutu Floodplain. Flowers close at night,
 re-open in morning.
 7611 *Buttonia superba* Oberm. 1357 Climber. Mahemane Thicket. Flowers open
 deep pink, fade to white over the days. Colour very variable.
 7614 *Graderia scabra* Benth. Herb. Agate hill, SW boundary fence.
 7625 *Striga forbesii* Benth. 47 Herb. Common on Pongola Floodplain.
S. gesneroides (Willd.) Vatke ex Engl. 627 Herb. Mahemane Thicket margins
 of floodplains.

(167) BIGNONIACEAE

- 7713 *Tecomaria capensis* (Thunb.) Spach 645 Shrub. Margins of Pongola Flood-
 plain. Infrequent.
 7722 *Rhigozum zambesiicum* Bak. 120 Shrub. Widespread in thicket, but not com-
 mon. Forms thickets occasionally. Spectacular sight after first rains—profuse
 blooming of yellow flowers. Lovely scent. Flowers eaten by beetles. Browsed by
 antelope.
 7761 *Kigelia africana* (Lam.) Benth. 1480 Tree. Usutu Floodplain. Flowers eaten
 off ground by antelope. Flowers appear with new leaves. Monkeys eat flower
 buds and flowers. Browsed.

(168) PEDALIACEAE

- 7777 *Sesamum alatum* Thonn. 445 Herb. Ndumu Hill. Common on disturbed ground.
- 7778 *Ceratotheca triloba* (Bernh.) Hook.f. 584 Herb. Usutu Floodplain. Found on roadsides. On S boundary in west, flowers very much smaller and deeper pink—ESP 1612.
- 7780 *Dicerocaryum zanguebarium* (Lour.) Merrill 1333 Climber. Usutu Floodplain. Long, prostrate stems. Nyala eat leaves and fruits.

(170) LENTIBULARIACEAE

- 7901 *Utricularia inflexa* Forsk. var. *inflexa* 590 Aquatic. Banzi pan.
U. inflexa Forsk. var. *stellaris* (L.) P. Tayl. 1576 Aquatic. Seasonal pools.
U. reflexa Oliver 1686 Aquatic. Channel across road to the bifurcation of the Pongola river.

(171) ACANTHACEAE

- 7914 *Thunbergia dregeana* Nees 1810 Climber. Ndumu Hill. Common in woodland.
- 7939 *Dyschoriste depressa* Nees 226 Herb. Pongola Floodplain.
- 7965 *Ruellia patula* Jacq. 208(Blue) 63(White) Herb. Common and widespread.
- 7972 *Crabbea nana* Nees 1386 Herb. Ndumu Hill; *Acacia nigrescens* Woodland in west.
- 7973 *Barleria crossandriiformis* C.B.Cl. 482 Scandent shrub. Mahemane Thicket.
B. delagoensis Oberm. 769 Shrub. Ulukondo. Sand Forest.
B. elegans S. Moore 470 Shrub. Widespread and common especially on floodplain margins. Seed pods burst open in the heat of the day, propelling the seeds some distance from the plant.
B. gueinzii Sond. 631 Shrub. Mkonjane, in thicket on rhyolite outcrops.
- 7978 *Schlerochiton caeruleus* (Lindau) S. Moore 346 Scandent shrub. Ulukondo. Common in Sand Forest. Scented flowers. Browsed.
- 7980 *Blepharis integrifolia* (L.f.) E. Mey. ex Schinz 1176 Herb. Mahemane Thicket.
B. sp. 1299
- 7985 *Crossandra fruticulosa* Lindau 43 Herb. Mahemane. Common in thicket. Flowers over a long period. Browsed.
C. greenstockii S. Moore 547 Herb. Agate hill, on S boundary fenceline in west.
- 8007 *Asystasia gangetica* (L.) T. Anders. 381 Herb. Ndumu Hill. Woodland.
- 8031 *Dicliptera clinopodia* Nees 503 Shrub. SW area of reserve. Faintly scented. Browsed.
D. heterostegia Presl ex Nees 492 Shrub. Usutu Riverine Forest.
- 8048 *Ecobolium amplexicaule* S. Moore 49 Herb. Mahemane. Common on disturbed ground.
- 8094 *Justicia* sp. aff. *J. anagaloides* T. Anders. 1588 Herb. Mkonjane. *Acacia nigrescens* Woodland.

Justicia capensis Thunb. 583 Shrub. Between Banzi and Inyamiti pans. Tongas use crushed leaves and stems to obscure human smell after setting snares (iKokela).

J. flava (Vahl) Vahl 11 Herb. Ndumu Hill. Common and fairly widespread.

J. glabra Roxb. 454 Shrub. Usutu Forest. Common, locally.

J. protracta (Nees) T. Anders. 1250 Herb. Mahemane Thicket. Browsed by nyala.

J. sp. 194 Herb. Ndumu Hill. Common.

8094a *Monechma debile* (Forsk.) Nees 1341 Herb. Usutu Floodplain.

(173) RUBIACEAE

8136/6 *K. autia lasiocarpa* Klotzsch var. *lasiocarpa* 536 Herb. Ndumu Hill. Flowers open in evening, closing next morning, scented.

K. virgata (Willd.) Bremek. var. *virgata* 899 Herb. Usutu Floodplain.

8136/14 *Agathisanthemum bojeri* Klotzsch subsp. *australe* Brem. var. *australe* 1237 Herb. Ndumu Hill. Woodland.

A. chlorophyllum (Hochst.) Brem. 4314 EJM Herb. Mahemane Thicket.

8136/18 *Pentodon pentander* (Schum.) Vatke 956 KLT Herb. East of Banzi pan.

8226 *Adina microcephala* (Del.) Hiern var. *galpinii* (Oliv.) Hiern 1683 Tree. Floodplains; Riverine Forest. Strong, unpleasant scent to flowers. Bark flakes off in long strips.

8278 *Tarenna barbertonensis* (Brem.) Brem. 699 Small tree. Usutu Riverine Forest.

8279 *Enterospermum littorale* Hiern 878 KLT Shrub. Ulukondo. Sand Forest.

8283 *Xeromphis obovata* (Hochst.) Keay 191 Shrub. Ndumu Hill. Common in woodland. Sweetly scented flowers. Browsed. Fruits eaten by Tongas (um-Khwakhwane).

X. rudis (E. Mey. ex Harv.) L. E. Codd 130 Shrub. Bunguzane. Fairly widespread, in thicket. Fruits eaten by Tongas. Heavily browsed.

8285 *Gardenia amoena* Sims 347 Shrub. Ulukondo. Sand Forest. Sweet scent quite different from the other *Gardenia* species. Fruits eaten by Tongas (iStempe-swane). Browsed.

G. cornuta Hemsl. 1183 Tree. Mahemane Thicket. Very common. Scent fills the air in mornings after rain. Monkeys eat buds and fruits. Bushpigs eat fruits. Antelope browse and eat fruits.

G. spatulifolia Stapf & Hutch. 172 Tree. Ndumu Hill. Woodland. Scented. Usually bloom after rain. Small groups of trees, widely scattered; fruits eaten by monkeys and antelope. Browsed.

8293 *Oxyanthus latifolius* Sond. 1411 Tree. E of Pongola Floodplain.

8308 *Tricalysia allenii* (Stapf) Brenan var. *kirkii* (Hook.f.) Brenan 140 Shrub. Ndumu Hill. Heavy sweet scent.

T. junodii (Schinz) Brenan 784 Shrub. Ulukondo. Sand Forest.

8308a *Kraussia floribunda* Harv. 163 Tree. Pongola Riverine Forest. Slightly scented flowers, attract many insects mostly flies. Coppice leaves very large and unlike mature leaves. Browsed. Fruits eaten by birds, monkeys, Tongas (amehlenkosasane).

8351 *Vangueria cyanescens* Robyns 916 Tree. Ndumu Hill. Woodland. Flowers scented, attract many insects particularly bees and wasps. Fruits eaten by antelope, monkeys, Tongas—refreshing on a hot day. Browsed (umViyo).

- Vangueria chartacea* Robyns 1266 Tree. Ulukondo. Sand Forest. Browsed. Fruits eaten by Tongas (umViyotshane).
- 8352 *Canthium locuples* (K. Schum.) Codd 968 KLT Ulukondo. Sand Forest.
C. obovatum Klotzsch 1110 Tree. Ulukondo. Sand Forest.
C. setiflorum Hiern 754 Shrub. Ulukondo. Sand Forest. Scented. Used for making Fonya (thrust) fishing baskets. Fruits eaten by Tongas—like raisins (umBhangwe).
C. spinosum (Klotzsch) Kuntze 1153 Shrub. Mahemane Thicket. Fruits eaten by Tongas (umVuthwamini). Used for making Fonya baskets.
- 8352a *Plectroniella armata* (K. Schum.) Robyns 1678 Shrub. S bank Inyamiti pan.
- 8352b *Dinocanthium hystrix* Bremek. 1143 Shrub. Mahemane Thicket. Browsed. Tongas do not use as firewood because it is used as a fence around graves.
- 8360 *Ancylanthus montei* Oliv. 158 Shrub. Ndumu Hill. Fruits eaten by tortoises, antelope, monkeys, Tongas (iStlilotshane).
- 8383 *Pavetta catophylla* K. Schum. 198 Shrub. Ndumu Hill. Woodland. Browsed. Fruits eaten by Tongas.
P. edentula Sond. 1033 KLT Tree. Rhyolite outcrops, Mkonjane. Scented flowers.
P. graciliflora Bremek. 314 Shrub. Banzi pan margins, in thicket.
P. inandensis Bremek. 350 Shrub. Ulukondo. Sand Forest.
P. lanceolata Eckl. 1102 Tree. Ulukondo. Sand Forest. Browsed.
P. schumanniana F. Hoffm. ex K. Schum. 787 Shrub. Ndumu Hill. Forming thickets in woodland. Heavy but unpleasant scent. Browsed. Fruits eaten by Tongas.
P. tristis Bremek. 408 Tree. Usutu Riverine Forest.
- 8464 *Richardia brasiliensis* Gomez 1691 Herb. Ndumu Hill. Woodland, on disturbed ground.
- 8473 *Borreria scabra* (Schumach & Thonn.) K. Schum. 417 Herb. Ndumu Hill. Common on disturbed ground.
- (176) CUCURBITACEAE
- 8562 *Mukia maderaspatana* (L.) M. J. Roem. 1345 Climber. Floodplains.
- 8564 *Zehneria parvifolia* (Cogn.) J. H. Ross ined. 605 Climber. Usutu Floodplain.
Z. scabra (L.f.) Sond. 806 Climber. Mahemane Thicket.
- 8568 *Kedrostis foetidissima* (Jacq.) Cogn. subsp. *obtusiloba* (E. Mey. ex Sond.) Meeuse 504 Climber. Ndumu Hill. Woodland.
K. hirtella (Naud.) Cogn. 671 Climber. Mkonjane. *Acacia nigrescens* Woodland in west.
- 8569 *Corallocarpus bainesii* (Hook.f.) A. Meeuse 342 Climber. Widespread.
- 8590 *Acanthosicyos naudinianus* (Sond.) Jeffrey 795 Climber. Ndumu Hill. Woodland.
- 8591 *Momordica clematidea* Sond. 414 Climber. Usutu Floodplain. Unpleasant scent.
M. foetida Schum. & Thonn. 406 Climber. Usutu Forest. Unpleasant scent.
M. involucreta E. Mey. 10 Climber. Ndumu Hill. Flowers have unpleasant scent, close at night, then drop. Birds, Tongas eat the fruits (uHaelane), which split open when touched at the pointed base.

- 8599 *Cucumis myriocarpus* Naud. 97b Climber. Pongola Floodplain edge.
- 8608 *Trochomeria hookeri* Harv. 948 Climber. Ndumu Hill. Woodland.
T. macrocarpa (Sond.) Hook.f. 1001 Climber. Ndumu Hill. Woodland.
- 8610 *Lagenaria mascarena* Naud. ex descr. 509 Climber. Usutu Riverine Forest.
 Pleasant scent. Climbs to a great height in forest. Large, heavy fruits hang from old woody stems.
- 8628 *Coccinia rehmannii* Cogn. var. *littoralis* A. Meeuse 344 Climber. Widespread.
 Flowers close at midday.
- (177) CAMPANULACEAE
- 8668 *Wahlenbergia undulata* DC. sens. lat. 25 Herb. Ndumu Hill. Flowers close at night, re-open next day.
- 8690 *Sphenoclea zeylanica* Gaertn. 1609 Herb. Seasonal pools. Stem becomes enlarged and spongy below water level.
- 8694 *Lobelia filiformis* Lam. var. *natalensis* (A.DC.) Wimm. 1656 Herb. Ndumu Hill. Seepage on main road near main gate.
- (179) COMPOSITAE
- 8734 *Ethulia conyzoides* L. 764 Herb. Pongola Floodplain.
- 8751 *Vernonia centaurioides* Klatt 477 Herb. Ndumu Hill. Woodland.
V. cinerea (L.) Less. 658 Herb. Floodplains.
V. colorata (Willd.) Drake 551 Shrub. Floodplains. Strongly scented. Many butterflies and insects attracted to flowers. *Charaxes* butterflies attracted to the oozing sap in great numbers. Browsed.
V. fastigiata Oliv. & Hiern 1598 Herb. Mkonjane. *Acacia nigrescens* Woodland.
V. glabra (Steetz) Vatke 5 Herb. Pongola Floodplain. Flowers open deep blue/purple—faded to paler colours by next day.
V. oligocephala (DC.) Sch. Bip. ex Walp. but approaching *V. natalensis* Sch. Bip. 718 Herb. Ndumu Hill. Woodland.
- 8795 *Ageratum conyzoides* L. 1424 Herb. Floodplains (introduced).
- 8818 *Mikania cordata* (Burm.f.) B. L. Robinson 635 Climber. Usutu Riverine Forest. Heavily scented flowers, not pleasantly. Many insects attracted to flowers.
- 8865 *Grangea maderaspatana* (L.) Poir. 831 Herb. Floodplains.
- 8900 *Aster squamatus* (Spreng.) Hieron 1689 Herb. Ndumu Hill, Pongola Floodplain (introduced weed).
- 8925 *Nidorella resedifolia* DC. 151 Herb. Ndumu Hill. Woodland.
- 8926 *Conyza bonariensis* (L.) Cronquist 1034 Herb. Ndumu Hill. Woodland (introduced weed).
- 8936 *Brachylaena huillensis* O. Hoffm. 883 Tree. Ndumu Hill. Used for spear shafts.
B. ilicifolia (Lam.) Phillips & Schweickerdt 1421 Tree. Mavilo 'island' on Pongola Floodplain.
- 8939 *Blumea mollis* (D. Don) Merrill 119 Herb. Pongola Floodplain.
- 8941 *Pluchea dioscoridis* (L.) DC. 612 Shrub. Usutu Floodplain. Aromatic scent to leaves and stems. Browsed.

- 8953 *Epaltes gariepina* (DC.) Steetz 74 Herb. Usutu Floodplain.
- 8955 *Sphaeranthus peduncularis* DC. 1307 Herb. Mahemane pools.
- 8992 *Gnaphalium calviceps* Fernald 6865 H&B Herb. Usutu Floodplain (introduced weed).
G. luteo-album L. 310 Herb. Pongola Floodplain (introduced weed).
G. pensylvanicum Willd. 656 Herb. Ndumu Hill. Common on roadsides (introduced weed).
G. polycaulon Pers. 132 HF Herb. Pongola Floodplain (introduced weed).
- 9006 *Helichrysum argyrosphaerum* DC. 655 Herb. Ndumu Hill. Woodland.
H. athrixiifolium O. Hoffm. 823 KLT
H. candolleianum Buek 608 Herb. Usutu Floodplain.
H. kraussii Sch. Bip. 607 Shrub. Usutu Floodplain. Common on white sands.
H. oxyphyllum DC. 215 Herb. Ndumu Hill. Woodland.
H. pilosellum (L.f.) Less. 215a Herb. Ndumu Hill. Woodland.
H. rugulosum Less. 214 Herb. Ndumu Hill. Woodland.
H. sp. c.f. H. setosum Harv. 606 Herb. Usutu Floodplain.
- 9090 *Geigeria burkei* Harv. subsp. *valida* Merxm 373 Herb. Mkonjane. *Acacia nigrescens* Woodland in west.
- 9130 *Acanthospermum hispidum* DC. 610 Herb. Usutu Floodplain (introduced weed).
- 9146 *Ambrosia artemisiifolia* L. 544 KLT Herb. Pongola Floodplain (introduced weed).
- 9166 *Eclipta prostrata* (L.) L. 410 Herb. Usutu Floodplain. Young plants' leaves are very large, stems have no air bladders. Older plants have large leaves at base, smaller and narrower above, with air bladders in stems (weed).
- 9204 *Melanthera scandens* (Schumach. & Thonn.) Roberty subsp. *dregei* (DC.) Wild 164 Herb. Pongola Riverine Forest.
- 9207 *Spilanthes mauritiana* (Persoon) DC. 575 Herb. Floodplains.
- 9237 *Bidens biternata* (Lour.) Merrill & Scherff 1621 Herb. Ndumu Hill (introduced weed).
- 9282 *Flaveria bidentis* (L.) Kuntze 306 Herb. Ndumu Hill (introduced weed).
- 9351 *Cotula anthemoides* L. 1463 Herb. Pongola Floodplain. Uncommon.
C. australis (Spreng.) Hook.f. 1631 Herb. Ndumu Hill (annual weed).
- 9411 *Senecio barbertonicus* Klatt 61 Succulent shrub. Common and widespread. Sweetly scented flowers. Browsed.
S. deltoideus Less. 593 Succulent climber. Usutu Floodplain. Wild-honey-like scent.
S. fulgens (Hook.f.) Nichols 15 Succulent. Mahemane Thicket. Browsed. Swollen rhizome eaten by bushpig.
S. macroglossus DC. 1 Succulent climber. Ulukondo. Sand Forest.
S. madagascariensis Poir. 652 Herb. Ndumu Hill. Petals (rays) fold in at night, open again next day.
S. pleistocephalus S. Moore 843 Succulent climber. Ndumu Hill. Widespread. Heavy honey-scented flowers. Corky bark on old stems. Dies back after flowering, re-shoots. Browsed.
S. polyanthemoides Sch. Bip. 760 Herb. Shokwe pan margins.

- Senecio quinquelobus* DC. 531 Succulent climber. Mahemane Thicket. Sweetly scented. Dies back in early summer, re-shoots.
S. transvaalensis Bolus 500 Herb. Mkonjane. *Acacia nigrescens* Woodland in west.
S. viminalis Bremek. 325 Succulent climber. Ndumu Hill. Woodland. Browsed. Blooms more than once in a good season.
- 9438 *Berkheya zeyheri* (Sond. & Harv.) Oliv. & Hiern subsp. *rehmannii* (Thell.) Roessler 206 Herb. Agate hill. *Acacia nigrescens* Woodland in west.
- 9528 *Gerbera ambigua* (Cass.) Sch. Bip. Herb. Drainage lines on Ndumu Hill; see ESP no. 440 from Otobotini.
- 9595 *Sonchus asper* (L.) Hill 1504 Herb. Pongola Floodplain (introduced weed). Tongas use with and as pumpkin shoots, 'imifino'—chopped up, boiled with curry and peanuts.
S. oleraceus L. 802 Herb. Pongola Floodplain (introduced weed).
- 9596 *Lactuca indica* L. 818 Herb. Pongola Floodplain.

REFERENCES

- ANDERSON, J. L. and POOLEY, E. S., 1977. Some plants identified in the rumina of Nyala antelope *Tragelaphus angasi* in Ndumu Game Reserve. *Lammergeyer* **23**: 40–45.
- COMPTON, R. H., 1966. An annotated check list of the Flora of Swaziland. *Jl S. Afr. Bot. Suppl.* vol. 6.
- DE MOOR, P. P., POOLEY, E. S., NEVILLE, G. and BARICHIEVY, J., in press. The vegetation of Ndumu Game Reserve, Natal. A quantitative physiognomic survey. *Ann. Natal Mus.*
- DIXON, J. E. W., 1966. Notes on the mammals of Ndumu Game Reserve. *Lammergeyer* **6**: 24–40.
- DUTTON, T. P., 1972. *Some factors affecting the fluctuating waterfowl populations on Lake Nyamiti*. Unpublished Research project, Field Ecology Course, University of Rhodesia. pp. 1–97.
- DYER, R. A., 1976. *Genera of Southern African Flowering plants*. 2 vols. Department of Agricultural Technical Services.
- FOSBERG, F. R., 1967. A classification of vegetation for general purposes. In: G. F. Peterken (ed.), *Guide to the check sheet for IBP areas*. pp. 73–116. Oxford: Blackwell Scientific publications.
- OATLEY, T. B., 1964. The probing of *Aloe* flowers by birds. *Lammergeyer* **3** (1): 2–8.
- POOLEY, A. C., 1968. A short note on the diet of the Vervet monkey *Cercopithecus aethiops* in Zululand. *Lammergeyer* **9**: 29–31.
- ROSS, J. H., 1972. Flora of Natal. *Mem. bot. Surv. S. Afr.* **39**.
- SCHELPE, E. A. C. L. E., 1970. *Pteridophyta. Flora Zambesiaca*. London: Crown Agents for Overseas Governments.
- SCOTCHER, J. S. B., 1974. *A quantitative assessment of the food preferences of Hippopotamus amphibius L. in the Ndumu Game Reserve, Tongaland*. Unpublished M.Sc. thesis. Pietermaritzburg: Department of Botany, University of Natal. pp. 1–190.
- TINLEY, K. L., 1964a. Fishing methods of the Thonga tribe in North-eastern Zululand and Southern Mozambique. *Lammergeyer* **3** (1): 9–39.
- , 1964b. *Summary of an ecological survey of Ndumu Game Reserve*. Unpublished roneoed report. Natal Parks Board. pp. 1–42.

ACKNOWLEDGEMENTS

I am indebted to Dr O. M. Hilliard for her enthusiastic encouragement over the years, for assistance and guidance in the task of collecting plants, and for her comments on this manuscript. I am very grateful to Dr K. D. Gordon-Gray for the time she has given to the naming of grasses and sedges, for taking great interest in my work at all times and for checking this manuscript. I wish to thank Miss L. Smook, Mrs J. Stewart, Mrs D. Fenn and Mr S. Mthlane, also of the Botany Department of the University of Natal, for their help. Mr B. L. Burtt, Royal Botanic Gardens Edinburgh, provided inspiration in the field and from abroad—and assisted greatly in putting names to some difficult specimens. Dr E. J. Moll, Dept. of Botany, University of Cape Town, kindly commented on parts of the manuscript and, with Mrs A. A. Mauve and Dr I. Verdoorn of B.R.I. Pretoria; Dr J. H. Ross of Melbourne, Australia; Mr C. J. Ward of University of Durban-Westville; have all been most helpful over the years. Mr C. F. Musil of Natal Herbarium is thanked for his assistance with queries regarding Lemnaceae. I am grateful to Dr P. P. De Moor, Res. Inst. for Diseases in a Tropical Environment, for the opportunity of participating in the vegetation survey.

I wish to thank the Natal Parks Board and the following staff for assistance and facilities provided: Mr. J. L. Anderson, Mr R. S. Crass, Mr R. Porter, Miss L. Roy, Dr D. R. M. Stewart, Mr J. Vincent. The Research Section of the Natal Parks Board very kindly made funds available for the publication of the maps. I am grateful to many of the past Ndumu staff for drawing attention to plants of interest, particularly to Mr and Mrs T. P. Dutton, Mr and Mrs G. O. Jackson, Mr and Mrs R. Physick, Mr and Mrs G. W. Schutte and to Mr and Mrs A. J. Tomkinson. Ex-game-guard Sigia Gumede gave valuable assistance in listing the edible plants.

Greatest thanks go to my husband Tony, whose interest and assistance, at all times, encouraged me to bring this work to completion. I am also indebted to my mother, Mrs E. K. Bond, who looked after our two sons whilst the herbarium work was carried out.

HABITAT OF THREATENED PROTEACEAE ENDEMIC TO WESTERN CAPE COASTAL FLATS

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ABSTRACT

Serruria ciliata, *Diastella buekii* and four species of *Leucadendron* are among members of the family Proteaceae endemic to the western coastal flats of the south-western Cape. These six species are associated with types of Coastal Fynbos or Coastal Rhenosterbosveld. Their habitats are compared using associated plants (Proteaceae and Restionaceae) as an expression of environmental conditions.

UITTREKSEL

HABITAT VAN BEDREIGDE PROTEACEAE ENDEMIES AAN DIE WESTELIKE KAAPSE KUSVLAKTES

Serruria ciliata, *Diastella buekii* en vier *Leucadendron* spesies is voorbeelde van lede van die familie Proteaceae wat beperkte verspreidings op die westelike kusvlakte van suidwes-Kaapland het. Hierdie ses spesies kom op verskillende tipes kusfynbos of kusrenosterbosveld voor. Hul habitate word met mekaar vergelyk op grond van geassosieerde plantsoorte (Proteaceae en Restionaceae) as weerspieëling van omgewingstoestande.

INTRODUCTION

The area occupied by natural vegetation on the western coastal flats of the south-western Cape (a land-unit, defined by Milewski & Esterhuysen, 1977), corresponding roughly to the western blocks of Acocks' [1975] Coastal Rhenosterbosveld and Coastal Macchia and the Breërivier valley east to Worcester) has been severely fragmented by man-made environmental changes. Several naturally rare plant species restricted to this area survive today only as relict populations and are threatened with extinction (Rare and Endangered Species Research Group, unpublished; Milewski & Esterhuysen, 1977). Knowledge of the phytogeographical relationships and habitats (*sensu* Whittaker *et al.*, 1973) of these localized habitat-specific endemics is an urgent prerequisite for their conservation.

This paper attempts a comparison of the habitats of several threatened endemic species in the family Proteaceae by a qualitative floristic method, using a sample of the plant taxa associated with each in its natural environment. Assumptions

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Accepted for publication 3rd May, 1977.

basic to this exploratory approach, which was similar to that of Milewski and Esterhuysen (1977) and Milewski (1977) were:

- (i) that the set of plant species growing at a site is an adequate and easily documented reflection of local environment in fynbos; the number of species in a given stand of this vegetation is relatively large (Taylor, in press), permitting more detailed characterisation of habitats by a floristic method than might be possible in vegetation dominated by another flora,
- (ii) that data on presence and absence of species are suitable and sufficient for such characterisation, in view of the high species-diversity in fynbos and the possibility that the relative importances of species have been changed by man-made disturbance, and
- (iii) that two families characteristic of fynbos (Taylor, in press), the Proteaceae and Restionaceae, constitute a representative sample of the taxa composing the vegetation and are sufficient for characterisation of habitats for comparative purposes.

Additional considerations leading to the choice of the Proteaceae as a sample group were that the study species are members of this family and that most genera are, or have already been, under taxonomic revision. The Restionaceae were in turn chosen partly because representatives of the family are invariably present in and thus characterise fynbos, and partly because the apparent habitat specificity of members of this large group makes them useful indicators of environment (Taylor, 1969, 1972a, in press; Boucher, 1972; Milewski & Esterhuysen, 1977).

The family Proteaceae is represented on the western flats of the south-western Cape by twelve species of *Leucadendron*, six species of *Leucospermum*, ten species of *Serruria*, three species of *Diastella* and six species of *Protea*. The following is a brief outline of the phytogeography of these groups in relation to the overall phytogeography of these flats.

Leucadendron salignum occupies the major part of the western flats and is widespread throughout the south-western Cape. The remaining 11 *Leucadendron* species occurring on the flats are all endemic, extending neither on to adjacent mountains nor on to the southern coastal flats east of Hangklip. *Leucadendron floridum*, *L. thymifolium*, *L. levisanus*, *L. verticillatum* and *L. flexuosum*, and the extinct *L. spirale*, have or had small, continuous areas of distribution. *Leucadendron lanigerum*, *L. corymbosum*, *L. cinereum*, *L. stellare* and *L. foedum* have wider ranges, those of *L. stellare*, *L. corymbosum* and *L. lanigerum* being disjunct. In addition to these 12 species, *Leucadendron chamelaeae*, *L. linifolium*, *L. brunoides*, *L. rubrum* and *L. spissifolium* extend marginally on to the flats from their main ranges elsewhere (Williams, 1972).

Three species of *Leucospermum*, viz. *L. parile*, *L. arenarium* and *L. tomentosum*, are endemic to small, continuous areas of distribution on the western flats. *Leucospermum hypophyllocarpodendron* and *L. rodolentum* have wider, disjunct

ranges centred on, but not restricted to, the flats. *Leucospermum grandiflorum* has a small range on part of the flats and adjacent foothills. In addition to these six species, *L. conocarpodendron* and *L. calligerum* extend marginally on to the flats from their main ranges on the mountains (Rourke, 1972).

Serruria burmannii parallels *Leucadendron salignum* as a widespread inhabitant of most of the western flats. *Serruria ciliata*, *S. trilopha*, *S. furcellata*, *S. linearis* and *S. roxburghii* are all endemic to the flats, having small areas of distribution; *S. decipiens* has a wider range but appears also to be endemic. *Serruria incrassata*, *S. aitonii*, *S. glomerata*, *S. cyanoides* and *S. brownii* occupy part of the flats and extend on to the adjacent foothills. In addition, *S. vallis* and possibly also *S. fucifolia*, both mountain species, extend marginally on to the flats (Rourke, in prep.).

Diastella parilis and *D. buekii* have small ranges on the flats adjacent to the foothills. *Diastella proteoides*, also endemic, has a wider distribution. In addition, *D. divaricata* has a range centred on the mountains and extending marginally on to the flats (Rourke, 1976).

Protea repens is a widespread member of its genus on the western flats, as are *Leucadendron salignum* and *Serruria burmannii*. *Protea pulchra* and *P. acaulos* also occupy the major part of the flats but extend on to the adjacent mountains. *Protea scolymocephala*, *P. odorata* and *P. mucronifolia* are endemic, *P. scolymocephala* having a wide range relative to the other two species. In addition, *P. arborea*, *P. laurifolia*, *P. cynaroides*, *P. lepidocarpodendron* and *P. macrocephala*, all mountain species, occur marginally on the flats (Rourke, in prep.).

Studies of Restionaceae (Milewski & Esterhuysen, 1977; Milewski, 1977) represent virtually the only available phytogeographical information dealing specifically with the western flats. Weimarck (1941), working with preliminary distribution data for a number of sample groups over the entire south-western Cape, treated this area merely as part of his "South-Western Centre", a phytogeographical land unit comprising both mountains and flats south and west of the Breede and Berg Rivers. He minimised the phytogeographical distinctiveness of these flats in comparison with surrounding mountains and the Bredasdorp limestone flats, stating: "The species occurring here have, as a rule, large distribution areas and are also abundant in a large part of the flats", and citing *Corymbium salteri*, *Echiostachys spicatus* and *Lobostemon paniculaeformis* as examples of the "very few" endemic species (Weimarck, 1941).

The restriction of three Restionaceous (Milewski & Esterhuysen, 1977) and 23 Proteaceous (above) species to the western flats calls for a revision of Weimarck's preliminary interpretation. The combination of an evident concentration of endemic taxa and intensive disturbance by man makes the western coastal flats a priority area for research towards plant conservation. Williams (1972), referring to *Leucadendron floridum*, stated: "There is no doubt that, unless this historic species is rigorously preserved, it will be extinct before long. It has already been

eliminated everywhere except in the Cape Point Nature Reserve, . . . where it is now being rapidly overwhelmed by the introduced Australian Port Jackson wattle [*Acacia saligna* Wendl., formerly *A. cyanophylla* Lindl.].” *Leucadendron levisanus*, another flats endemic, was formerly “abundant” near Cape Town: “urban development and the spread of the introduced *Acacia cyanophylla* Lindl., have however virtually eliminated it from the Peninsula and it is fast approaching extinction” (Williams, 1972).

METHODS

Six study species in the family Proteaceae were chosen for the following characteristics:

- (1) endemism to a small continuous geographical range (maximum 700 km²) within the western coastal flats, arbitrarily defined (Milewski & Esterhuysen, 1977) as from False Bay northwards, west of the Hottentots-Holland-Winterhoek mountain chain to S 32 ° 30' and eastwards along the intermontane flats to Worcester, between sea level and 600 m altitude, and
- (2) small size and deteriorating conservation status of remaining total species-population owing to man-made environmental changes (number of known extant plants of each study species less than 1 000).

The study species, all evergreen perennials, were:

- (i) *Serruria ciliata* R. Br.,
- (ii) *Leucadendron verticillatum* (Thunb.) Meisner,
- (iii) *Leucadendron flexuosum* Williams,
- (iv) *Leucadendron floridum* R. Br.,
- (v) *Leucadendron levisanus* (L.) Berg., and
- (vi) *Diastella buekii* (Gandoger) Rourke.

Methods were essentially similar to those used by Milewski (1977). Severe limitations on the thoroughness of the investigation were imposed by the study species' relict status. All known remaining populations of each study species were investigated, “populations” of a species being arbitrarily defined (Milewski & Esterhuysen, 1977) as stands farther than 2 km apart. Data were recorded from two populations of all study species except *Diastella buekii* (until recently thought extinct [Rourke, 1976]; a single rediscovered population was investigated) and *Leucadendron verticillatum* (3 populations investigated). The physiognomy and general floristics of associated vegetation were subjectively recorded for each population.

Indirect (floristic) information was mainly used in comparing the habitats of the study species. The four *Leucadendron* species grow as 1.0–2.0 m high, densely branched, erect woody shrubs arising from a single stem; the two *Serruria* species, forming 0.5–1.0 m high shrubs, have similar growth-form. *Diastella*

buekii grows as a dense "mat" (diameter 1.0–2.0 m) of creeping soft-woody stems, originating from a single base at ground level and rooting adventitiously. All species in the Proteaceae and Restionaceae growing within 0.5 m of plants of each study species were recorded, data thereby being collected only within the edaphic environment of the study species (plants of the study species cover a larger area than do the herbaceous Restionaceous species studied by Milewski, 1977, necessitating a greater radius of investigation).

The search for members of these two families was continued until the list of associates for each population appeared complete, i.e. until not more than one new associate species was found with ten successively visited study plants, or until a minimum of 20 plants, scattered throughout the population, had been investigated. Lists, according to presence or absence, of associate species for each population were combined to show the "between-population frequency" of each associate for each study species. A list from one population of *Serruria ciliata* (apparently var. *congesta*) was not included in the associate data, since the associated vegetation appeared very different from that in which the typical form of the species grew, and owing to the undecided taxonomic status of *S. ciliata* var. *congesta* at the time of writing (Rourke, pers. comm.).

RESULTS AND DISCUSSION

1. General account of habitats

Serruria ciliata was restricted to deep, pale Tertiary sand on the northern Cape Flats (Rourke, in prep.). The associated vegetation was a mainly restioid-ericoid (*sensu* Taylor, in press) Coastal Fynbos, 1.0–1.5 m high. The species occurred near Bellville and Bottelary as scattered plants with e.g. *Berzelia abrotanoides*, *Staavia adriata*, *Cliffortia polygonifolia* and *Passerina vulgaris* in stands similar to those associated with *Chondropetalum acockii* and *Restio micans* (Milewski & Esterhuysen, 1977). *Serruria ciliata* var. *congesta* grew near Faure in vegetation different in appearance, resembling Taylor's (1972b) *Thamnochortus-Passerina* Fynbos of Reddish Sands, with the ericoid shrub *Passerina vulgaris*, the tufted restioid *Thamnochortus erectus*, the low spreading shrub *Myrica quercifolia* and several members of the Proteaceae and Restionaceae (Appendix 1).

Leucadendron verticillatum was restricted to "fairly level" substrates "with a clay subsoil" in "a small area where the divisions of Bellville, Paarl, Malmesbury and Stellenbosch adjoin each other" (Williams, 1972). The associated vegetation was an ericoid-restioid form of Coastal Rhenosterbosveld (*sensu* Taylor, in press). The species occurred on the slopes of the Joostenberg as scattered emergent plants in an open stand (canopy cover 40–50%) comprising a main 0.7–0.9 m stratum dominated by the "heath-like" shrub *Elytropappus rhinocerotis*, and a ground stratum of wiry restioids (e.g. *Restio cuspidatus*) and forbs. *Leucadendron verticillatum* occurred near Hercules Pillar as 2.5–3.0 m emergent shrubs in similar

vegetation, with 1,0–1,5 m proteoid (*Leucadendron lanigerum*), broad-leaved (e.g. *Olea africana*) and ericoid (e.g. *Eriocephalus africanus*) shrubs.

Leucadendron flexuosum occurred only on "level alluvial soil containing a large percentage of waterworn stones" in a small area of "the Breede River Valley near Worcester" (Williams, 1972). The associated vegetation was an ericoid-restioid dry fynbos. The species grew near Hartebeest River Bridge as scattered plants forming a 1,8 m emergent stratum in an open stand (canopy cover 40–50 %) comprising a main 0,3–0,4 m stratum of ericoid and other small-leaved shrubs (e.g. *Elytropappus gnaphaloides*, *Eriocephalus africanus*, *Relbania squarrosa*, *Cliffortia ruscifolia*) and wiry restioids (e.g. *Restio cuspidatus*). Another population of *Leucadendron flexuosum* near Hartebeest River Bridge occurred as groups of plants forming, with shrubs of *Dodonaea viscosa*, a 1,0 m stratum emergent from a main stratum of tufted restioids (e.g. *Thamnochortus sporadicus*) and ericoid shrubs.

Leucadendron floridum was restricted to sandy soil on the Cape Flats and valleys of the Cape Peninsula (Williams, 1972). The associated vegetation was a mainly graminoid-ericoid (*sensu* Taylor, in press) fynbos intermediate in appearance between Coastal Fynbos and Mountain Fynbos. The species occurred near Kommetjie and between Scarborough and Klaasjagersberg in dense stands (canopy cover 80–90 %), comprising 1,0–2,0 m high tussock restioids (e.g. *Restio compressus*) and other graminoids (e.g. *Neesenbeckia punctoria*), and ericoid and other shrubs (e.g. *Berzelia abrotanoides*, *Erica* spp., *Psoralea aphylla*), and a poorly defined lower stratum of sprawling soft shrubs (e.g. *Cliffortia subsetacea*) and tufted restioids (e.g. *Elegia fistulosa*). This vegetation appeared similar to Taylor's (1969) *Berzelia-Osmitopsis* Seepage Scrub Association and *Restionaceus* Tussock Marsh Association.

Leucadendron levisanus occurred only "on sandy soil . . . on the Cape Flats from the Fish Hoek valley north to the Koeberg" (Williams, 1972). The species formed a scattered emergent stratum of 1,0–1,5 m shrubs in restioid-ericoid vegetation similar to that associated with *Serruria ciliata*. *Leucadendron levisanus* has previously been recorded growing with other emergents, e.g. *Thamnochortus erectus* and *Passerina vulgaris*, among plants of e.g. *Aspalathus hispida*, *Carpobrotus acinaciformis*, *Crassula cymosa*, *Psoralea fruticans*, *Rhus laevigata* and *Ehrharta villosa* (Taylor, 1972b).

Diastella buekii was restricted to "sandy situations", on "the floor of the upper Berg River valley" (Rourke, 1976). The associated vegetation was a mainly restioid-ericoid fynbos intermediate in appearance between Coastal Fynbos and Mountain Fynbos. The species occurred near Wemmershoek as scattered plants in an open stand (canopy cover 50–70 %) comprising a main 0,6–0,7 m stratum of tufted restioids (e.g. *Thamnochortus sporadicus*, *Chondropetalum nudum*, *Staberoha cernua*) and ericoid shrubs (e.g. *Cliffortia juniperina*, *Lachnospermum fasciculatum*, *Euryops abrotanifolius*, *Lachnaea capitata*, *Phylica stipu-*

TABLE 1

Restionaceous and Proteaceous associate species, according to "between-population frequency", of six Proteaceous study species: 1 = *Leucadendron floridum*, 2 = *Leucadendron levisanus*, 3 = *Serruria ciliata*, 4 = *Diastella buekii*, 5 = *Leucadendron flexuosum*, 6 = *Leucadendron verticillatum*. Numerator is the number of populations in which the associate was recorded within 0.5 m of plants of each study species; denominator is the total number of investigated populations of each study species; "+" indicates associates recorded in the same stand of vegetation as the study species but not within 0.5 m.

Associate species	Occurrence with study species					
	1	2	3	4	5	6
<i>Elegia fistulosa</i> Kunth	/2					
<i>Restio compressus</i> Rottb.	2/2					
<i>Diastella divaricata</i> (Berg.) Rourke	1/2					
<i>Leucadendron laureolum</i> (Lam.) Fourcade	1/2					
<i>Restio dodii</i> Pillans	1/2					
<i>Elegia cuspidata</i> Mast.	1/2					
<i>Elegia asperiflora</i> (Nees) Kunth	2/2	+				
<i>Serruria glomerata</i> (L.) R.Br.	2/2	1/2				
<i>Restio tetragonus</i> Thunb.	2/2	1/2				
<i>Serruria ciliata</i> R.Br.		1/2				
<i>Restio triticeus</i> Rottb.		1/2				
<i>Elegia verreauxii</i> Mast.		+				
<i>Elegia prominens</i> Pillans		+				
<i>Restio sabulosus</i> Pillans		+				
<i>Protea scolymocephala</i> Reich.		+	+			
<i>Restio micans</i> (Kunth) Nees		1/2	1/2			
<i>Thamnochortus punctatus</i> Pillans		1/2	1/2			
<i>Diastella proteoides</i> (L.) Druce		+	1/2			
<i>Leptocarpus impolitus</i> (Kunth) Pillans			2/2			
<i>Leucadendron levisanus</i> (L.) Berg.			1/2			
<i>Leucadendron cinereum</i> (Solander ex Ait) R.Br.			1/2			
<i>Chondropetalum acockii</i> Pillans			1/2			
<i>Thamnochortus obtusus</i> Pillans			1/2			
<i>Protea pulchra</i> Rycroft			1/2			
<i>Staberoha distachya</i> (Rottb.) Kunth			1/2			
<i>Protea repens</i> (L.) L.			+			
<i>Serruria furcellata</i> R.Br.			+			
<i>Leucospermum hypophyllocarpodendron</i> (L.) Druce			2/2	1/1		
<i>Hypodiscus aristatus</i> (Thunb.) Nees			+	1/1		
<i>Restio curviramis</i> Kunth				1/1		
<i>Restio filiformis</i> Poir.				1/1		
<i>Restio pedicellatus</i> Mast.				1/1		
<i>Restio monanthus</i> Mast.				1/1		
<i>Restio wallichii</i> Mast.				+		
<i>Thamnochortus sporadicus</i> Pillans				1/1	2/2	
<i>Restio</i> sp. nov. 1				+	2/2	
<i>Cannomois acuminata</i> (Thunb.) Pillans					2/2	
<i>Leucospermum calligerum</i> (Salisb. ex Knight) Rourke					1/2	
<i>Leucadendron brunioides</i> Meisn.					+	

TABLE 1 (contd)

Associate species	Occurrence with study species					
	1	2	3	4	5	6
<i>Leucadendron chamelae</i> (Lam.) Williams					+	
<i>Thamnochortus bachmannii</i> Mast.					1/2	+
<i>Restio duthieae</i> Pillans						3/3
<i>Leucadendron lanigerum</i> Buek ex Meisn.						2/3
<i>Elegia squamosa</i> Mast.						2/3
<i>Hypodiscus paludosus</i> Pillans						2/3
<i>Elegia</i> sp. nov. Esterhuysen 34411						2/3
<i>Restio triflorus</i> Rottb.						2/3
<i>Protea odorata</i> Thunb.						1/3
<i>Restio quinquefarius</i> Nees	2/2	1/2	1/2			
<i>Restio bifurcus</i> Nees ex Mast.	1/2	1/2	1/2			
<i>Chondropetalum nudum</i> (Nees) Rottb.	2/2	2/2	+	1/1		
<i>Elegia vaginulata</i> Mast.	2/2		+	1/1		
<i>Elegia neesii</i> (Mast.) Mast.	2/2			1/1		
<i>Elegia coleura</i> Nees ex Mast.	1/2				1/2	
<i>Chondropetalum tectorum</i> (L.) Pillans		1/2	1/2			
<i>Willdenowia sulcata</i> Mast.		+	2/2	1/1		
<i>Willdenowia humilis</i> Mast.		+	1/2	1/1		
<i>Hypodiscus willdenowia</i> (Nees) Mast.		+	1/2	1/1		
<i>Staberoha cernua</i> (L.f.) Dur & Schinz	2/2	+	1/2	1/1	2/2	
<i>Restio paludosus</i> Pillans	1/2	1/2	+	1/1	1/2	
<i>Leucadendron salignum</i> Berg.		+	1/2	1/1	2/2	
<i>Elegia parviflora</i> Kunth	1/2	2/2	1/2		1/2	1/3
<i>Restio</i> sp. nov. 2		+			1/2	
<i>Willdenowia arescens</i> Kunth			2/2		1/2	
<i>Leptocarpus rigoratus</i> Mast.		1/2			1/2	2/3
<i>Chondropetalum rectum</i> (Mast.) Pillans		1/2				2/3
<i>Serruria burmanii</i> R.Br.		+		1/1	1/2	+
<i>Leptocarpus vimineus</i> (Rottb.) Pillans			+	1/1	1/2	+
<i>Restio cuspidatus</i> Thunb.			+	1/1	2/2	3/3
<i>Restio</i> sp. nov. 3			+			1/3
<i>Thamnochortus fruticosus</i> Berg.			+			1/3
<i>Willdenowia striata</i> Thunb.				+	+	+

laris). Scattered proteoid, ericoid and other shrubs (e.g. *Leucadendron salignum*, *Passerina vulgaris*, *Berzelia abrotanoides*, *Anthospermum aethiopicum*, *Rhus angustifolia*, *Diospyros glabra*) emerged to 1,2 m.

2. Habitat similarity

Table 1 shows sets of Proteaceous and Restionaceous associates for the study species. The column sequence in Table 1 interrelates the study species on the basis of associates shared, owing to the arrangement of rows and columns. Table 2 shows percentage similarity between these sets.

Similarity values were generally low; the only pairs of species showing more than 30% similarity between sets of associates were *Leucadendron floridum* with

TABLE 2

Percentage similarity between sets of associates for six study species of Proteaceae, using "between-population frequency" data on Proteaceous and Restionaceous associates (Table 1) to calculate the Czekanowski coefficient. The formula used was $\frac{2w}{A+B} \times 100$ (Bray & Curtis, 1957), where w = number of associate species in common, A = number of associates for one study species, and B = number of associates for another study species.

	Study species					
	1	2	3	4	5	6
1. <i>Leucadendron floridum</i> R.Br.		36,4	15,1	21,3	20,0	3,9
2. <i>Leucadendron levisanus</i> (L.) Berg			29,3	11,4	15,8	15,0
3. <i>Serruria ciliata</i> R.Br.				27,3	17,0	4,1
4. <i>Diastella buekii</i> (Gandoger) Rourke					34,2	4,7
5. <i>Leucadendron flexuosum</i> Williams						17,4
6. <i>Leucadendron verticillatum</i> (Thunb.) Meisn. ...						

L. levisanus, and *Diastella buekii* with *Leucadendron flexuosum*. *Leucadendron verticillatum* and *L. flexuosum* had sets of associates largely different (17,4% similar) from each other and from those for the other two congeneric study species (3,9–20,0% similar). The set of associates for *Serruria ciliata* was more similar to that for *L. levisanus* (one of its associates) than to those for any other study species.

This numerical assessment of similarities can be viewed as a reflection of habitat similarity for the study species, based on the assumptions set out in the introduction. The habitats of the study species thus appear in general to be distinct from each other.

3. Discussion

Leucadendron levisanus, *L. floridum* and *Serruria ciliata* all formerly occurred in partial sympatry on the northern Cape Flats. Each of the remaining three study species was allopatric with all other study species.

Leucadendron levisanus and *L. floridum*, largely sympatric, have been recorded from the same localities (Williams, 1972). A difference in their habitats has, however, been hinted at in the literature: *L. levisanus* has been recorded from "sandy soil, often very damp in winter", while *L. floridum* "is always found growing near to streams or in damp places . . . it will grow with its roots submerged for long periods in waterlogged ground" (Williams, 1972). The chief habitat difference between these two congeners thus appears to be their different, although possibly overlapping, tolerance ranges with regard to soil moisture. *Serruria ciliata* evidently also has a discrete association with relatively poorly drained substrates, ranging from those supporting *L. levisanus* to better drained sands supporting the very habitat-specific *Chondropetalum acockii* (the habitats of

Chondropetalum acockii and *Restio micans*, associates respectively of *S. ciliata* and *L. levisanus*, have been described by Milewski & Esterhuysen, 1977).

The habitat of *Diastella buekii*, as expressed by its set of associates, is more similar to those for *L. levisanus* and *S. ciliata* than to that for *L. verticillatum*; the habitat of *Leucadendron flexuosum* appears equally similar to these two groups. The sand associated with *D. buekii*, probably of transported Table Mountain Sandstone origin, is apparently that of an intermontane alluvial plain, as is the substrate associated with *L. flexuosum*. However, *D. buekii* receives more than twice the average annual precipitation (800–900 mm, localities given by Rourke, 1976) received by *L. flexuosum* (300–400 mm, localities given by Williams, 1972), which grows on the edge of the Karoo.

The interrelationships of the habitats of the study species, thus interpreted from sets of associates, agree with the author's field impressions. The evident interrelationships of the vegetation associated with the study species, assessed subjectively on the basis of physiognomy and general floristics, also support these conclusions.

The main variation in the vegetation of the western flats appears to be in response to two edaphic gradients, the first determined by the proportions of sand and clay in the soil and the second by site drainage (e.g. Talbot, 1971; Taylor, 1969, 1972b, in press). The sand-clay ratio evidently results, at the extremes of the range, in the basic dichotomy outlined by Acocks (1975) and Taylor (in press), that of Coastal Fynbos (*Coastal Macchia*) on deep pale Tertiary sand and Coastal Rhenosterbosveld on clay-rich soil weathered from Malmesbury shale. *Leucadendron levisanus*, *L. floridum* and *Serruria ciliata* are species of the sand biotope, while *Leucadendron verticillatum* is a species of the clay biotope. *Leucadendron flexuosum* can perhaps be regarded as a species of an intermediate, relatively dry environment; *Diastella buekii* can perhaps be regarded as a species of a sandy environment intermediate between the Coastal Fynbos and Mountain Fynbos (i.e. Acocks' *Macchia* on Table Mountain Sandstone) biotopes.

The apparent dissimilarity between the habitats of the study species, including those which grow in geographical proximity in apparently similar environments, reflects the complex floristic pattern within Coastal Fynbos and Coastal Rhenosterbosveld. Preservation of as wide a range as possible of coastal flats endemics and the plant communities in which they occur calls for the strict preservation of all remaining relics of natural vegetation until a detailed phytocenological survey can provide the basis for optimal placing of permanent flora reserves.

ACKNOWLEDGEMENTS

I wish to thank Professor E. A. C. L. E. Schelpe for the use of facilities at the Bolus Herbarium, University of Cape Town. Dr A. V. Hall, project leader of the Rare and Endangered Plant Species Research Group, supervised the study. Miss E. Esterhuysen and Dr J. P. Rourke gave freely of their expertise, and assisted with identification of Restionaceae and Proteaceae respectively. Dr E. J. Moll, Dr P.

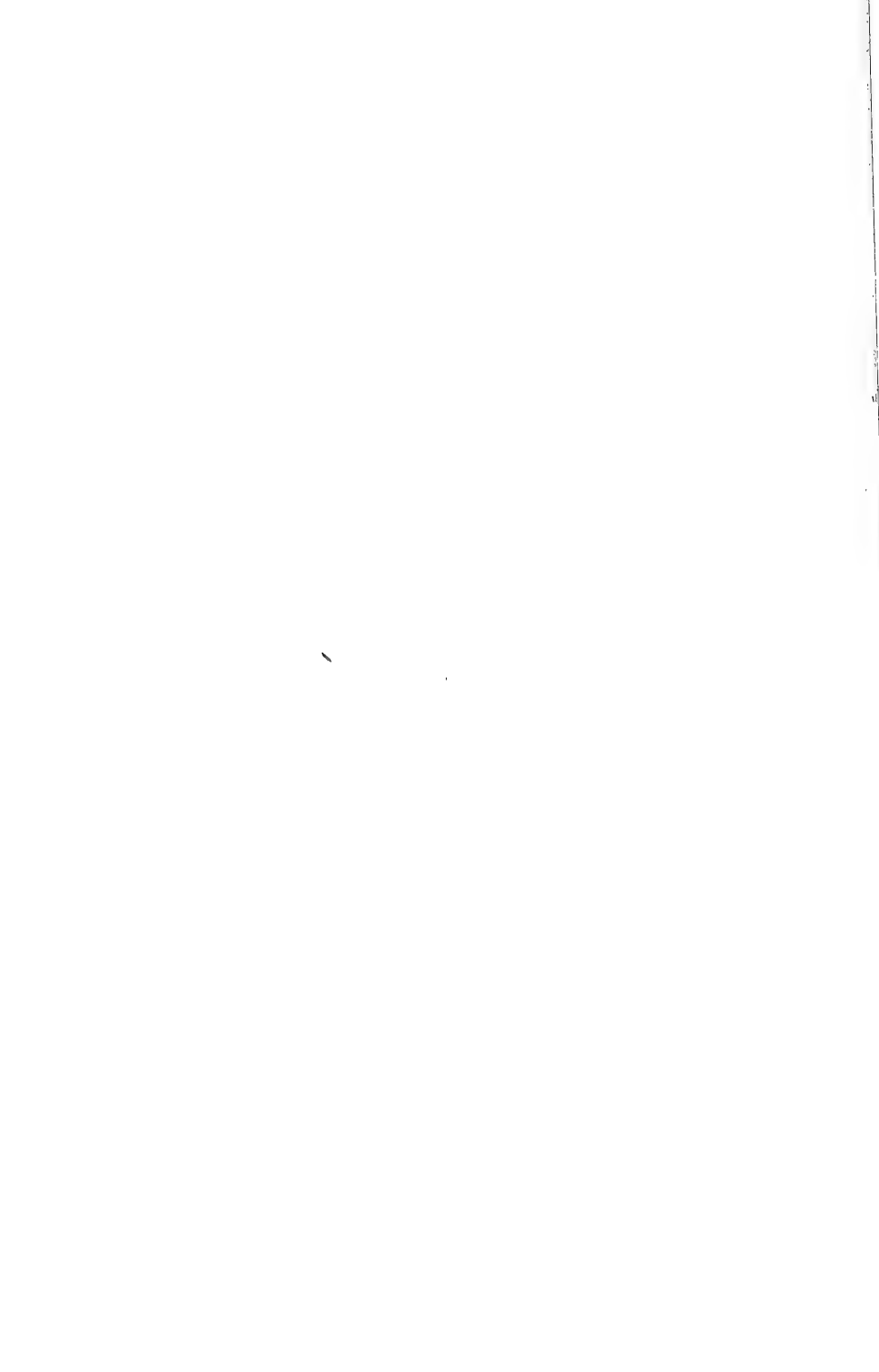
Bridgewater and Mr H. P. Linder commented on the manuscript. Financial assistance provided under the National Programme for Environmental Sciences is gratefully acknowledged. I am indebted to Mrs M. L. Jarman and Miss C. Davidge for typing the manuscript.

REFERENCES

- ACOCKS, J. P. H., 1975. Veld types of South Africa. *Mem. bot. Surv. S. Afr.* **40**.
- BOUCHER, C. 1972. *The vegetation of the Cape Hangklip area*. M.Sc. thesis. Cape Town: University of Cape Town.
- BRAY, R. J. and CURTIS, T. T., 1957. An ordination of upland forest communities of southern Wisconsin. *Ecol. Monogr.* **22**: 325-349.
- MILEWSKI, A. V. and ESTERHUYSEN, E., 1977. Habitat of Restionaceae endemic to western Cape coastal flats. *Jl S. Afr. Bot.* **43** (4): 233-241.
- MILEWSKI, A. V., 1977. Habitat of Restionaceae endemic to the south-western Cape coastal flats. *Jl S. Afr. Bot.* **43** (4): 243-261.
- RARE AND ENDANGERED SPECIES RESEARCH GROUP. Unpublished reports on distribution, habitat and status of threatened plant taxa in the south-western Cape, 1976. Cape Town: Bolus Herbarium, University of Cape Town.
- ROURKE, J. P., 1972. Taxonomic studies on *Leucospermum* R.Br. *Jl S. Afr. Bot. Suppl.* vol. 8.
- ROURKE, J. P., 1976. A revision of *Diastella* (Proteaceae). *Jl S. Afr. Bot.* **42** (3): 185-211.
- ROURKE, J. P., in preparation. A revision of the genus *Protea* L.
- ROURKE, J. P., in preparation. A revision of the genus *Serruria* Salisb.
- TALBOT, W. J., 1971. South western Cape Province. *The South African landscape: 1*. South African Geographical Society.
- TAYLOR, H. C., 1969. *Vegetation of the Cape of Good Hope Nature Reserve*. M.Sc. thesis. Cape Town: University of Cape Town.
- TAYLOR, H. C., 1972a. Fynbos. *Veld & Flora* **2**: 68-75.
- TAYLOR, H. C., 1972b. Notes on the vegetation of the Cape Flats. *Bothalia* **10** (4): 637-646.
- TAYLOR, H. C., in press. Phytogeography and ecology in Capensis. In: M. J. A. Werger (ed.), *Biogeography and ecology in Southern Africa*. The Hague: Junk.
- WEIMARCK, H., 1941. Phytogeographical groups, centres and intervals within the Cape Flora. *Acta Univ. lund. N.F. Avd.* **2**, 37 (5).
- WHITTAKER, R. H., LEVIN, S. A. and ROOT, R. B., 1973. Niche, habitat and ecotope. *Am. Nat.* **107** (955): 321-338.
- WILLIAMS, I. J. M., 1972. A revision of the genus *Leucadendron* (Proteaceae). *Contr. Bol. Herb.* **3**.

Appendix 1: Restionaceous and Proteaceous associates of *Serruria ciliata* var. *congesta* (100 plants investigated in 1 population).

Leucadendron salignum, *Protea scolymocephala*, *Serruria burmannii*, *Thamnochortus erectus*, *Thamnochortus fruticosus*, *Thamnochortus obtusus*, *Hypodiscus willdenowia*, *Elegia vaginulata*, *Willdenowia striata*, *Chondropetalum nudum* and *Restio cuspidatus*.



STUDIES IN THE GENUS *CASSIA* IN SOUTH AFRICA: 2. NOTES ON *CASSIA ITALICA* (MILL.) LAM. EX F. W. ANDR.

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ABSTRACT

Two characters (stigma form and ovary indumentum) previously unused in subspecific delimitation within *Cassia italica* (Mill.) Lam. ex F. W. Andr. are considered and additions are made to features already useful in infraspecific classification in this taxon. Two subspecies, the one comprising three forms, are confirmed for the species in southern Africa and distributional ranges for the taxa are given. Some previously perplexing variants are clarified.

UITTREKSEL

'N STUDIE VAN DIE GENUS *CASSIA* IN SUID-AFRIKA:

2. AANTEKENINGE OOR *CASSIA ITALICA* (MILL.) LAM. EX F. W. ANDR.

Twee kenmerke (stempelvorm en ovariumbehaaring) wat voorheen nie in die afbakening op subspecies-vlak in *Cassia italica* (Mill.) Lam. ex F. W. Andr. gebruik is nie, word in oorweging geneem en word tot kenmerke wat alreeds nuttig is in die indeling op infraspecies-vlak in hierdie takson gevoeg. Twee subspecies, een bestaande uit drie forms, word bevestig vir die spesies in suidelike Afrika en die verspreidings vir die taksons word aangegee. 'n Paar variante waaroor daar voorheen onduidelikheid was, word toegelig.

Brenan (1958) outlined the wide geographical range of *Cassia italica* (Mill.) Lam. ex F. W. Andr. and analysed its "... remarkable range of variation, ...". On leaf, inflorescence and flower characters, this author was able to recognize three races which he appropriately designated subspecies because of their mostly distinct distributions and because of occasional inconsistencies in the correlated characters by which they were distinguished. Table 1 gives a summary of these distinctions and of the geographical ranges of the subspecies as determined by this author. The southern race, subsp. *arachoides*, is undoubtedly the most variable. Much South African material corresponds with the holotype of this subspecies (South Africa, Griqualand West, *Burchell 1680*, K), but Brenan (1958) enumerated three variants that diverge from this type and he listed other "... perplexing specimens ...".

In revising *Cassia* for the *Flora of Southern Africa*, it became necessary to take up the study of this subspecies and of subsp. *micrantha*, both of which reach the Flora area, and to pursue the "perplexities" that Brenan had so ably exposed.

This subsequent study has revealed the presence within *C. italica* of two characters convenient in infraspecific diagnosis that were unused by Brenan.

Accepted for publication 19th July, 1977.

These are:

1. *Stigmatic form*

In subsp. *arachoides* the style is long and more or less coiled: it terminates in a stigmatic zone only slightly wider than the style breadth which narrows again to end in a small more or less circular opening (Fig. 1a, b; Fig. 2b, c).

In subsp. *micrantha* the style is visibly shorter and does not coil, but merely recurves towards the ovary: the terminal stigmatic zone is clearly wider than the style and asymmetrically trumpet shaped (better developed adaxially than abaxially) with an opening as wide as the stigmatic expansion. In herbarium specimens the delicate margin of this stigmatic tissue is usually reflexed, but this is not often the case in living flowers (Fig. 1c; Fig. 2a).

In the few specimens of subsp. *italica* I have examined, the stylar and stigmatic form agreed precisely with that of subspecies *arachoides*. Probably this could do with further checking.

Because style and stigma persist after pollination and can be seen clearly exposed on young developing fruits, the form of these structures provides a useful means by which to distinguish the subspecies *micrantha* and *arachoides*. The criterion seems reliable (as is to be expected considering the use that has been made of stigmatic form in aiding the delimitation of genera in papilionates, for example *Dolichos* and its allies, Verdcourt, 1970), for among the more than 200 specimens examined, only one possible intermediate was encountered (see *De*

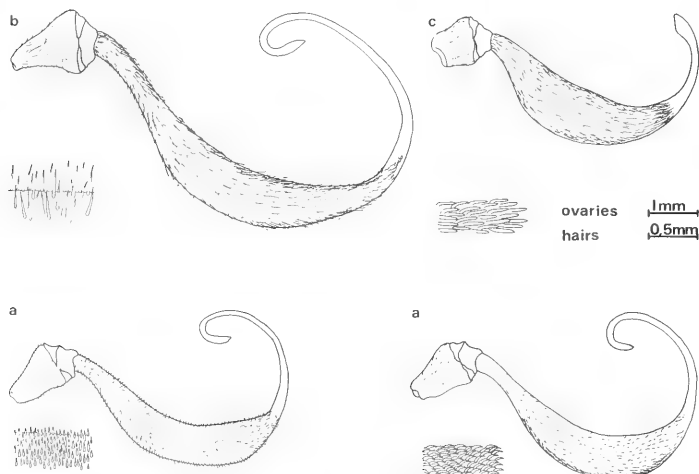


FIG. 1.

CASSIA ITALICA, developing ovaries with their indumentum types: a. subsp. *arachoides* minute-haired form with trichomes patent (left) and curved (right); b. subsp. *arachoides* villous form; c. subsp. *micrantha*.

Winter & Leistner 5756 later) but this had clearly the stigmatic structure of subsp. *micrantha*.

2. *Indumentum of developing ovary and mature legume*

Vesture, together with some consideration of the hair types comprising it, has been used before in infraspecific classification within *C. italica*. Burt Davy (1932) established *C. obovata* var. *pilosa* for plants with stems, rachises and leaves pilose, while Brenan (1958) included indumentum among the characters he used (see Table 1). No author yet seems to have commented upon the indumentum of, or its absence from, young ovaries or mature fruits. This may be because the trichome types present are those of the vegetative organs, but on the ovaries in particular, the hairs are closely packed and thus readily observed, especially as the outer floral parts fall away after fertilization to leave the young ovaries exposed. This character aids particularly in the recognition of variants within subsp. *arachoides*, but can be used as an additional means by which to distinguish the two subspecies.

In the subspecies *micrantha* ovaries are densely clothed in curved, appressed, white hairs which give them an almost hoary appearance (Figs 1c: 2f). Occasionally some of these hairs are swollen and inversely bottle-shaped (perhaps serving as water reservoirs?). As growth and maturation of the fruit takes place, the hairs become spaced so that the mature valves are sparsely appressed-pubescent.

In subsp. *arachoides* the indumentum is not uniform and four variants or forms may be recognized:

<i>Variant</i>	<i>Ovary</i>	<i>Legume</i>	<i>Trichome type</i> (representative of whole plant)
A (typical form)	glabrous	glabrous	short, straight, patent, scattered (Fig. 3a, g)
B (minute-haired form)	densely appressed- pubescent	sparsely appressed- pubescent	minute, curved appressed (Figs. 1a, right; 2d; 3d)
C (minute-haired form)	densely pubescent	sparsely pubescent	minute, straight, patent (Figs. 1a, left; 2e; 3f)
D (villous form)	densely villous	villous	long, slender, straight, patent, fine hairs (Figs. 1b; 2g; 3h)

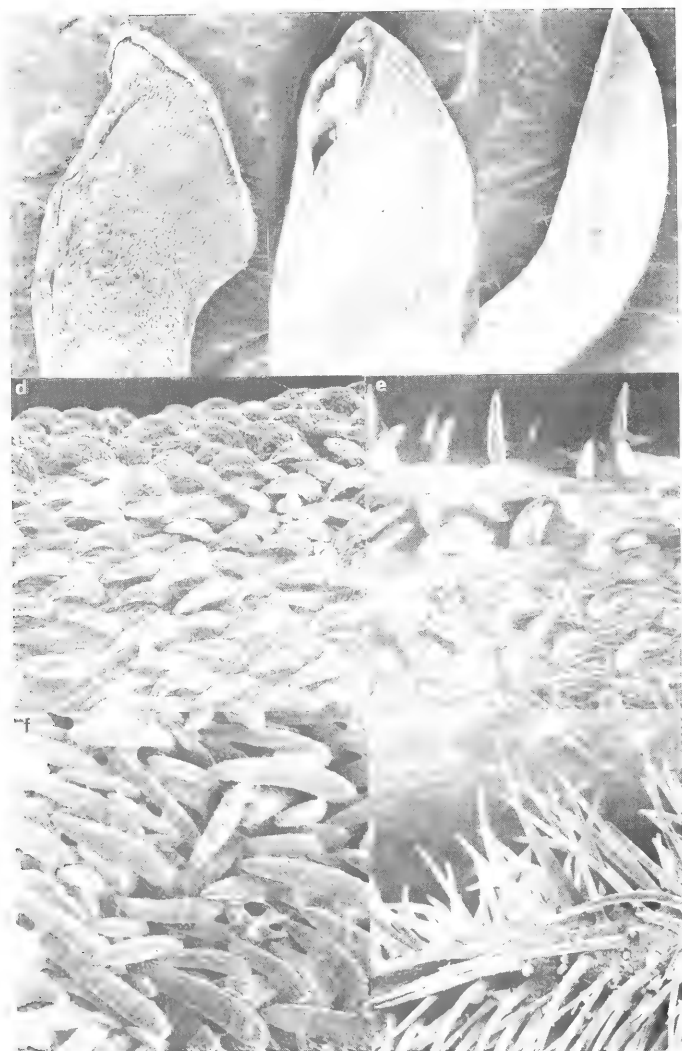


FIG. 2.

CASSIA ITALICA, scanning electron micrographs of: a. subsp. *micrantha*, stigma (X 105); b. & c. subsp. *arachoides*, stigma (X 105); d. subsp. *arachoides* minute-haired form (trichomes curved), ovary indumentum (X 300); e. ditto but trichomes patent (X 300); f. subsp. *micrantha*, ovary indumentum (X 300); g. subsp. *arachoides* villous form, ovary indumentum (X 135).

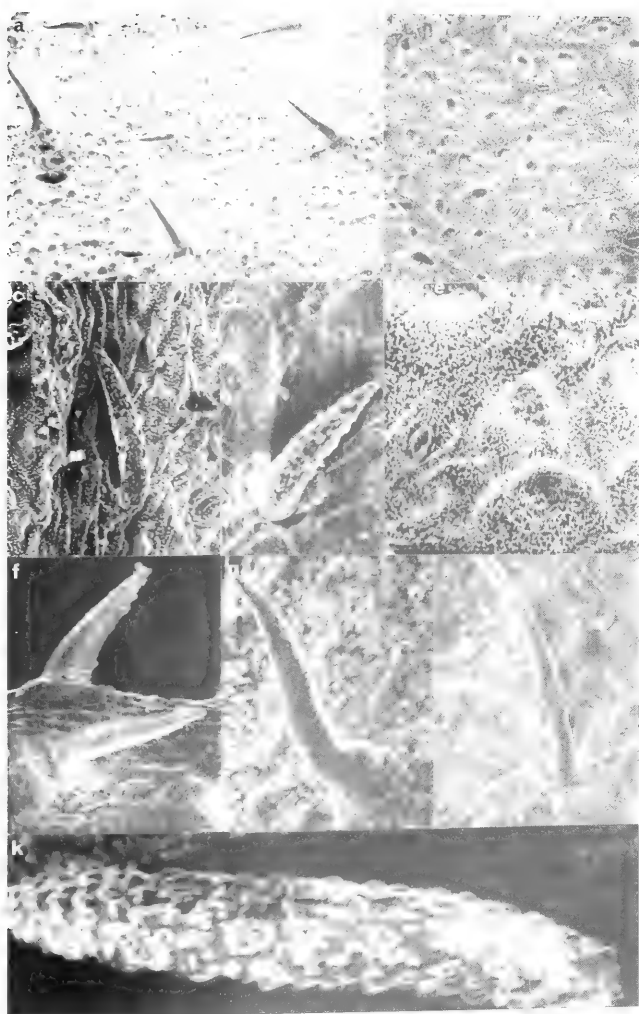


FIG. 3.

CASSIA ITALICA, scanning electron micrographs of: a. subsp. *arachoides* typical form, leaf surface showing trichomes and papillae (X 125); b. ditto, papillae enlarged (X 200); c. ditto, further enlarged, note stoma (X 800); g. ditto, single trichome enlarged (X 600); e. subsp. *micrantha*, leaf surface showing single trichome (X 600); k. ditto, further enlarged (X 1625); d. subsp. *arachoides* minute-haired form, leaf surface showing single curved trichome (X 600); f. ditto showing two patent trichomes (X 600); h. subsp. *arachoides* villous form, leaf surface showing base of trichome and several stomata (X 300).

On the basis of stigma type and indumentum it has been possible to clarify one of the doubts expressed by Brenan, 1958, and to provide a few more facts relevant to the understanding of infraspecific variation in *C. italica*.

Burt Davy 7040 (K) from hotel-yard at Pienaars River Station, Transvaal, that was doubtfully determined by Brenan l.c. as subsp. *micrantha*, has been re-examined by Dr J. H. Ross, SA Liaison Officer at Kew, whom I should like to thank. This specimen has the stylar form typical of subsp. *arachoides*. It is therefore in accord with distributional patterns of variants within *C. italica* determined in the present study, for no specimens of subsp. *micrantha* have been found further east than *Lugard 201* from Kwebe Hills, Botswana, approximately S 20° 40'; E 23° 5' (also cited by Brenan, 1958).

The only other specimen seen that did not immediately fall within one or other subspecies on the basis of the two characters mentioned above was *De Winter & Leistner 5756* from Otjinungua, north western South West Africa. This has the stylar form of subsp. *micrantha* but the indumentum of subsp. *arachoides*, to which taxon it was referred by Schreiber, 1967. (I prefer to place it with subsp. *micrantha* as, in my opinion, it also agrees with this taxon in petiole length, inflorescence/leaf ratio and leaflet apex). It is from an area where both these subspecies are thought to be sympatric (but this must be checked on the ground, if possible). Such a specimen suggests that outbreeding is possible between these subspecies, as would be expected.

From study of the indumentum of ovary and fruit in the considerable amount of material of subsp. *arachoides* available in herbaria, it has been possible to gain better knowledge of, and roughly to delimit the areas occupied by, the variants within this subspecies, some of which were listed by Brenan 1958: 243.

Variant A represents the typical form of subsp. *arachoides*. Here ovary and fruit are glabrous. Plants are sometimes described as glabrous and glaucous. The latter epithet is well applied, but strictly plants are not glabrous for magnification reveals scattered *short* straight patent hairs on leaves and stems that Brenan referred to as "Indumentum saepius breve, sparsum, patens . . ." (Fig. 3a). Often on young stem apices in particular, and especially in plants growing where environments are extreme, the hairs are interspersed with small, short-stalked or subsessile elliptical glands that impart a certain viscosity. The leaves are also often papillate as is clearly revealed by electron scanning (Fig. 3a, b, e). This typical form is the "dryland" variant within subsp. *arachoides*, for plants occupy harsh, sub-desertic environments in South West Africa, Botswana, the northern central Cape Province, the Orange Free State and the western Transvaal (Fig. 4). A majority of southern African plants belong with this form.

Variants B and C represent Brenan's variant (2). These plants are green, not glaucous, and again appear glabrous to the naked eye, but microscopic examination reveals minute hairs more closely packed than in the typical form. Ovaries and fruits are hairy, not glabrous. In some plants (variant B) the hairs are curved

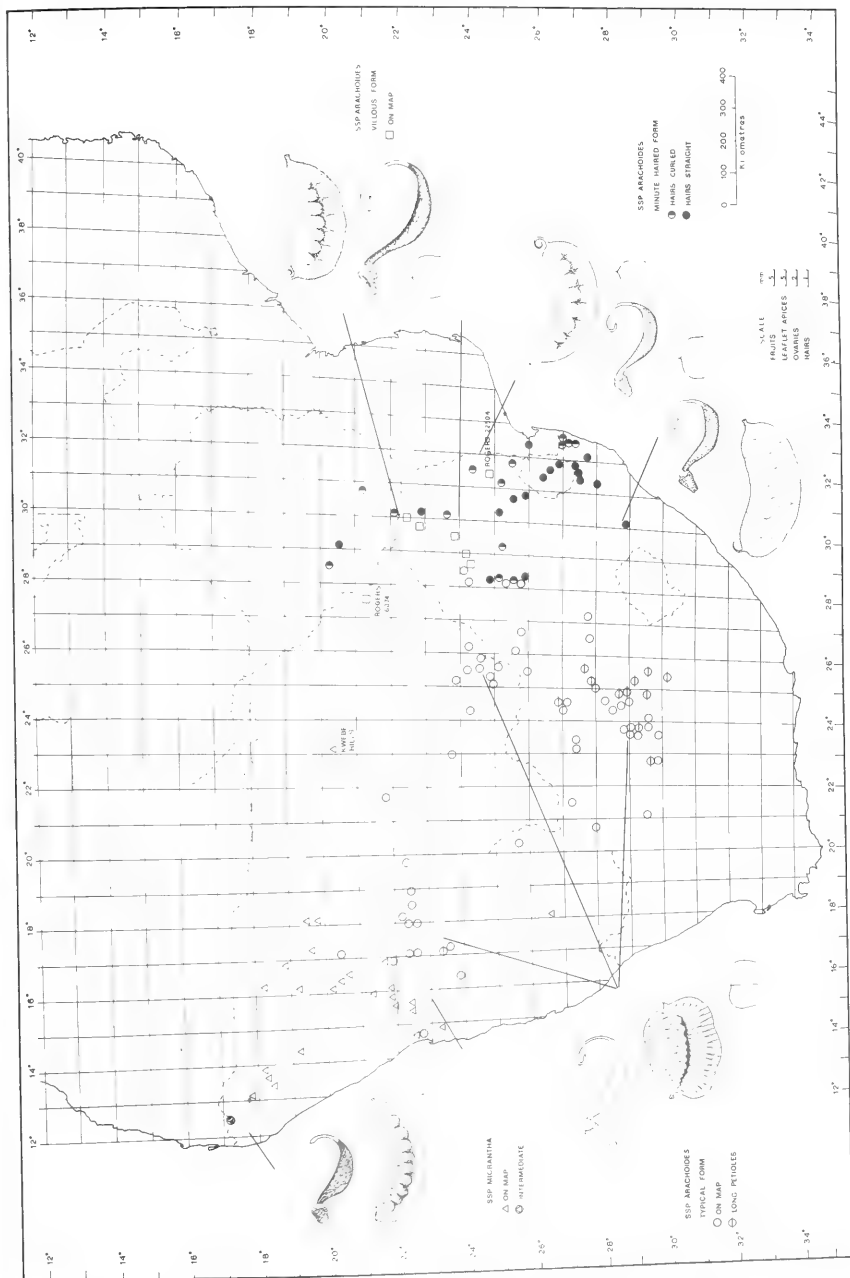


FIG. 4.

CASSIA ITALICA, distribution of subspp. and forms in southern Africa. Marginal illustrations show quary, fruit and leaflet apex for each subspp. and form.

and appressed; in other plants (variant C) the hairs are straight and patent. Brennan did not differentiate between the two hair types, so it is uncertain whether he noticed them or not. Of the specimens he cites I have not seen *Trapnell 744* from Natal, but *Barnard & Mogg 966* and *Codd & De Winter 5009*, both from the Transvaal, have curved hairs. Natal and Swaziland plants more commonly have straight, patent hairs, while those from the Transvaal are often curved, but this is not absolute.

These minute hairs, be they curved or straight, are distinguishable *under magnification* ($\pm \times 20$) from the hairs of subsp. *micrantha* and from hairs of the typical form of subsp. *arachoides*. Especially on the ovaries is this the case, for the longer appressed hairs of subsp. *micrantha* overlap to a degree that the minute hairs do not (compare Fig. 2d, e, f). This minute-haired form is the "moist-land" variant within subsp. *arachoides*. This appellation is, nevertheless, something of a misnomer, for plants, like those of the typical form, also occur in open, dry habitats, but such conditions in eastern Southern Africa are far less harsh than are the sub-desertic conditions of the west. The minute-haired form occurs in Rhodesia, Moçambique, Swaziland, the Transvaal and Natal as far south as the Tugela Valley. In the Transvaal it is mainly central and eastern: towards the west there is overlap with the typical form.

Variant D represents Brennan's (1958: 242) variant (1) and, as this author stated, is also probably the form that Burt Davy (1932: 325, Type: *Rogers 22504*, Transvaal, Pilgrims Rest distr., Newington—not seen by me) established as *C. obovata* var. *pilosa* (non *Senna obovata* (Collad.) Batka var. *pilosa* Batka which is *Cassia italica* subsp. *italica*). Also probably belonging here is *Moss & Rogers 36*, which Baker (1930) and following him Burt Davy (1932) tentatively placed with *C. holosericea* Fresen., which is a north-east African species with villous pubescence resembling that of Variant D, but with smaller flowers and pods that lack a line of crests.

Variant D is the villous form within subsp. *arachoides*. The hairs to the ovary, mature legume, peduncle and the vegetative organs are long, fine, straight, patent and closely packed so that the indumentum is villous. Brennan cited only three specimens of this form, but the present survey has shown that it is well established in the Transvaal north of S 25° and between E 28°–30° 30'. *Rogers 6074* from Francistown, Botswana is not quite as evidently hairy to the naked eye as are most specimens referred to this form. If this gathering and *Rogers 22504* are included in variant D, then its distributional limits are extended slightly east and west.

Other characters correlated with variation within C. italica

3. Leaflet apex

Burt-Davy (1932: 325) established *C. obovata* var. *mucronata* (Type: *Galpin 750*, Transvaal, Barberton, near Queen's River) for plants in which the leaflets are drawn out into a mucron 0.5 to 1.0 mm long. It is not necessary to maintain this

taxon, for this character appears to be correlated with the development of minute hairs, so that it is a feature of the minute-haired form of subspecies *arachoides*. It is not limited to this entity, however, because plants of subsp. *micrantha* usually develop leaflets with similar mucronate apices. In contrast, the typical form of subsp. *arachoides* generally has emarginate leaflet apices. The only deviation from this is in occasional plants where whole leaves (and their leaflets) are very much larger than usual and are assumed to have developed during exceptionally favourable growth periods. The apices to these larger leaflets are rounded rather than emarginate, sometimes with a poorly-defined mucron. In the villous form of subsp. *arachoides* apices vary from more or less emarginate, to rounded, sometimes with a poorly-defined or short mucron.

4. Legume crests and legume shape

In *C. italica*, each valve of the legume develops a lengthwise midline of discrete, small evaginations called "crests". Burt-Davy (1932: 325) described *Galpin 750* (type of his var. *mucronata*) as bearing pods lacking crests, but on the several sheets of this gathering in various herbaria, some pods show some evidence of evaginations. Study has shown that it is rather exceptional to find all legumes developed by a plant without trace of crests but sometimes they are scarcely discernible as in the (straight) minute-haired form in Natal (*Ward 3613*, PRE, NH, NU). Small, poorly-defined crests are known only among plants from eastern southern Africa: thus this feature seems correlated with the minute-haired form, but it is by no means always developed here, however, and as Brenan (1958: 243) suggested, seems no more than a chance variation.

Legume shape also shows variation. This seems to correlate in part at least with the taxa already recognized within *C. italica*. Pods of plants of the typical form of subsp. *arachoides* are usually more or less sub-orbicular with glabrous valves on which the veins are clearly marked (Fig. 4), whereas pods of all other variants including subsp. *micrantha* develop longer, narrower, more or less oblong pods, in which the valves carry an indumentum and where the veins are usually less obvious (Fig. 4). It is tempting to think these differences in shape are the result of differences in rates of growth concomitant with the differing environments under which the plants grow, but this is not supported in the case of fruits of subsp. *micrantha*.

5. Petiole length

Reference to Table 1 shows that Brenan (1958) recognised subsp. *arachoides* as having shorter petioles than either of the other two subspecies. Thus he found perplexing certain specimens which, while agreeing with other characters of this taxon, yet possessed long petioles. Some of these specimens otherwise resembled the holotype of subsp. *arachoides*; others belonged with the minute-haired variant. In attempting an explanation for these long petioles, Brenan considered that they

might be produced on young actively growing shoots, or that they might result from introgression of subsp. *micrantha* into subsp. *arachoides*.

During the present study a number of points have become clear:

- (i) within the distributional range of the typical form of subsp. *arachoides* it is not unusual for short petioled leaves to be succeeded *on the same stem* by leaves with much longer petioles (*Werger 235*, Orange Free State, Hopetown distr. near Luckhoff, has leaves with petioles ranging roughly in sequence from 5.0–15 mm (Fig. 5)). Also in occasional localities, plants with petioles up to 19 mm long have been repeatedly collected. These localities mostly lie between S 26°–30° and E 23°–26° and include the Herbert district and Bloemhof from where, respectively, *Burchell 1764* and *Leistner 53* (both cited by Brenan, 1958: 243) were obtained. Other localities and specimens worth mentioning are: Vryburg, Armoedsvlakte, *Sharpe 7056*; Bloemhof, Kameelpan, Christiana, *Theron 427*; Prieska, *Bryant J178*. Then, too, in other dry areas such as South West Africa, a single gathering may be much more robust and larger in all its vegetative parts than other specimens from the same general locality (*Ihlenveldt 1888*, South West Africa, distr. Rehoboth, farm Bergland).
- (ii) Within the minute-haired form it is usual for leaves to have petioles longer than the range given by Brenan (1958) for subsp. *arachoides* (see Table 1). Apart from the specimens of this group cited by Brenan as “perplexing”, there are many others that exhibit the same feature (*Edwards 3189*, Natal, Ngotshe distr., 1½ ml. from Pongola bridge on Magudu road, carries leaves with petioles from 10–18 mm long on the same plant).
- (iii) Considering the range in petiole length recorded for leaves on single stems, it seems probable that within the typical form of subsp. *arachoides* at least, this is a seasonal, or a habitat, phenomenon associated with favourable growing conditions. This is surely not unexpected considering the response that usually results from the presence of moisture in inhospitable environments. On the basis of present distributions it seems unlikely that introgression from subsp. *micrantha* is the explanation underlying these longer petioles since most specimens are known from near the south eastern distributional limit of the typical form. But what is the explanation underlying the presence of the villous form of subsp. *arachoides* in the Pietersburg area of the Transvaal and probably further north? Is this a case of introgression, but with a taxon not now represented there?

6. Relative lengths of leaves and inflorescences and flower size

Brenan, 1958, collectively used three characters to classify *C. italica* at infraspecific level. These were:



FIG. 5.
CASSIA ITALICA subsp. *arachoides* typical form: Werger 235 from near Luckhoff, stem showing variation in leaf and leaflet size.

TABLE 1.
Characters used by Brenan (1958) to differentiate subspecies within *C. italica*

	subsp. <i>italica</i>	subsp. <i>micrantha</i>	subsp. <i>arachoides</i>
petiole length	mostly 10-35 mm	mostly 10-25 mm	mostly 3-12 mm
raceme length	60-230 mm	20-80 mm	70-220 mm
raceme length: subtending leaf length	mostly raceme exceeding subtending leaf, sometimes subequal	raceme shorter than subtending leaf	mostly raceme exceeding subtending leaf
sepal length	8,0-13,0 mm	5,0-8,0 mm	8,0 mm
petal length	9,0-20,0 mm	8,5-9,0 mm	10,0-12,0 mm
petal width	5,0-10,0 mm	3,5-4,5 mm	5,0-6,0 mm
anther lengths			
longest	8,0-14,0 mm	5,5-6,0 mm	8,0 mm
medium	4,0-6,0 mm	2,5-3,5 mm	2,5-3,0 mm
shortest	1,5-2,5 mm	1,25 mm	1,0 mm
indumentum	appressed-puberulous, occasionally shortly spreading-pubescent	appressed-puberulous	often short, sparse, spreading, rarely dense, or appressed-puberulous
distribution	Cape Verde Is., Senegambia & Rio de Oro to Egypt & Somaliland & south to Nigeria, the Sudan & Ethiopia. Also Israel, Arabia, Persia, Baluchistan & n.w. India.	Ethiopia, British Somaliland, Uganda, Kenya, Tanzania, Botswana & South West Africa. Also most of India.	Rhodesia, Moçambique, South West Africa, Botswana, Swaziland & South Africa.

(a) ratio of subtending leaf length to inflorescence length

(b) petiole length

(c) flower size

He was careful to stipulate that none of these characters *considered separately* was absolute in enabling distinction to be made among the three subspecies, *italica*, *micrantha* and *arachoides*. The present work has shown that when these criteria are used (and they are helpful) the following additional attributes will make them easier to apply and more reliable in differentiation:

- (i) inflorescence length for comparison against subtending leaf length: ideally measurement should take place as the first flower opens.

TABLE 2.

Main features useful in differentiating subspecies and forms within *Cassia italica* in southern Africa.

subspecies forms	<i>arachoides</i>	typical	<i>micrantha</i> minute-haired	villous
stigma	trumpet-shaped (Fig. 2a)	contracted into an aperture narrower than style (Fig. 2b, c)		
style	curved, \pm 3-4 mm long (Fig. 1c)	more or less circinnate, 6-7 mm long (Fig. 1a, b)		
ovary indumentum	hoary	lacking	hoary	villous
ovary trichomes	see Fig. 1c; 2f	lacking	see Fig. 1a; 2d, e	see Fig. 1b; 2g
leaf trichomes	microscopic appressed	short, patent sparse (almost microscopic)	microscopic straight or curved	villous
petiole length in mm	9-23 (-25)	(3-)6-12(-19)	8-15(-20)	(3-)5-12
leaflet apex	mucronate	emarginate to rounded	mucronate	emarginate to rounded
petal length in mm	5-7(-9)	7,0-12,0	7,0-12,0	10,0-18,0
Pods	\pm oblong trichomes short, appressed scattered	\pm suborbicular glabrous, veins clearly marked	\pm oblong trichomes minute, crests sometimes \pm lacking	\pm oblong villous
distribution	S.W. Africa; Botswana	S.W. Africa; Botswana; N. Cape; W. to central Transvaal	Swaziland; central & E. Transvaal; N. Natal & Tugela Basin	N. Transvaal; Botswana

(ii) petiole length and flower sizes: it is necessary to give a range for each attribute separately for each form or variant within this subspecies and not collectively for subsp. *arachoides*.

These additions are given in Table 2 which may serve as a summary for infraspecific variation within *C. italica* as this is presently known in South West

Africa, Swaziland and South Africa. A key permitting identification of the infraspecific taxa within *C. italica* represented in these countries is provided.

The following conclusions may be drawn:

1. No plants with *all* the size dimensions of subsp. *italica* have been seen from the area covered by the *Flora of Southern Africa*. There is no doubt, however, that the subsp. *italica* and *arachoides* are closely allied and differ quantitatively rather than qualitatively.
2. Subsp. *arachoides* is the most variable of the three subspecies and comprises three forms: the typical form (A) limited to the more arid parts of southern Africa, namely, S.W. Africa, Botswana, the western Transvaal and the north-western and northern Cape Province; the minute-haired form (B, C) represented in eastern southern Africa (the central and eastern Transvaal, Swaziland and Natal as far south as the Tugela river valley, also in Rhodesia, and Mocambique); the villous form (D) represented in the northern Transvaal (also probably in Rhodesia).

It has not been considered necessary to cite specimens additional to those listed by Brenan (1958).

It is interesting to postulate why subsp. *micrantha* should possess a stigma different from that of both other subspecies and why its distribution should be limited to India and central Africa and especially the latter where it breaks the distributional continuity of the stylar type representative of subsp. *italica* and *arachoides*. Can this be attributed to introgression by genetic material of a species of *Cassia* present in India and Central Africa, but absent elsewhere from the range of *C. italica*? *C. tora* in India and *C. obtusifolia* in Tropical Africa are closely related to one another and have a stigmatic form that might account for that of subsp. *micrantha*. All three taxa belong to the subgenus *Senna*, but to different sections of this subgenus. All have been recorded as possessing races with 14 chromosomes in the gametophytic phase (Irwin & Turner, 1960). Experimental breeding is required to test this postulate.

A duplicate of one of the syntypes of *C. obovata* Collad. var. *pallidiflora* Dinter in Feddes Repert. **15**: 355 (1918) (*Dinter 366*, Okahandja) is preserved at the South African Museum Herbarium (SAM). This specimen agrees with other specimens of subsp. *micrantha* from South West Africa cited by Brenan (1958) and thus Dinter's variety may now be accepted as falling within the limits of subsp. *micrantha*. Brenan (*l.c.*) stated that no syntypes of Dinter's variety were still in existence at Berlin and duplicates had been looked for in vain in the herbaria at Hamburg, the British Museum (Natural History) and Kew.

SCANNING ELECTRON MICROGRAPHS

The micrographs illustrating this paper were prepared in the following way: representative stigmas and pieces of ovaries and mature leaves removed from

herbarium specimens were mounted on stubs using double-sided adhesive tape. After drying for 24 hours in a desiccator, the specimens were coated in vacuum with gold-palladium to a thickness of less than 150 Å, then examined in a Hitachi SSM2 scanning electron microscope at a voltage of 10 kV. The images were observed at a magnification range 100– and photographed with a 35 mm camera.

KEY TO SUBSPECIES AND FORMS REPRESENTED IN SOUTHERN AFRICA

- Stigma (usually visible even on developing fruits) expanded to exceed the width of the style, asymmetrically trumpet-shaped (better developed adaxially than abaxially); style 3–4 mm long, curved but not \pm circinnate; flowers pale yellow to cream, brown veined; racemes, when only basal flowers are open, 20–80 mm long, usually shorter than the subtending leaf subsp. **micrantha**
- Stigma (usually visible even on developing fruits) hardly expanded (subterminally only to slightly exceed style width) narrowing terminally to form an aperture usually narrower than the style; style 6–7 mm long, \pm circinnate; flowers bright yellow, brown veined only with age; racemes, when only basal flowers are open, mostly 60–150 mm long, usually longer than the subtending leaf subsp. **arachnoides**
- Ovary glabrous typical form (A)
- Ovary bearing trichomes
 Trichomes long, fine \pm straight, closely packed so as to form a villous pubescence villous form (D)
- Trichomes short (microscopic) rather thick for their length, straight or curved, closely packed when ovary very young minute-haired form (B & C)

ACKNOWLEDGEMENTS

I wish to thank Miss L. Cowan, Mrs B. Loutit and Messrs V. Bandu, P. Evers, B. Martin, R. Poonsamy and D. Tunnington for help in the preparation of illustrations; Dr J. H. Ross for the checking of specimens, and the Curators of Herbaria for the loan of material. Financial assistance from the Council of Scientific and Industrial Research is gratefully acknowledged.

REFERENCES

- BAKER, E. G., 1930. *The Leguminosae of Tropical Africa*. Ostend: Unitas Press, pp. 636–637.
- BRENAN, J. P. M., 1958. New and noteworthy Cassias from Tropical Africa. *Kew Bull.* **13**: 239–243.
- BURTT DAVY, J., 1932. *A manual of the flowering plants and ferns of the Transvaal with Swaziland, South Africa* **2**: 325. London: Longmans, Green & Co.
- DINTER, K., 1918. Index der aus Deutsch-Südwestafrika bis zum Jahre 1917 bekannt gewordenen Pflanzenarten II. *Feddes Rep.* **15**: 355.
- IRWIN, H. S. AND TURNER, B. L., 1960. Chromosomal relationships and taxonomic considerations in the genus *Cassia*. *Am. J. Bot.* **47**: 309–318.
- SCHREIBER, A., 1967. Caesalpinaceae. In: *Prodromus einer flora von Südwestafrika* **59**: 11.
- VERDCOURT, B., 1970. Studies in the Leguminosae—Papilionoideae for the Flora of Tropical East Africa: III. *Kew Bull.* **24** (3): 379–447.

NUCLEOLAR HETEROCHROMATIN IN *ENCEPHALARTOS*

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ABSTRACT

Using a denaturation-reannealing-fluorescence technique to illustrate the position of heterochromatin, it is shown that during interphase in the root tip cells of *Encephalartos* a close association occurs between heterochromatin and the nucleoli. The possible significance of this is discussed.

UITTREKSEL

NUKLEOLÊR HETEROCHROMATIEN IN *ENCEPHALARTOS*

Die gebruik van 'n denaturering-hergloei-fluoreserende tegniek om die posisie van heterochromatien te illustreer, toon dat daar in die wortelpunt selle van *Encephalartos* gedurende die interfase 'n nou assosiasie tussen die heterochromatien en die kernliggaampies is. Die moontlike betekenis hiervan word bespreek.

INTRODUCTION

The functions of heterochromatin, i.e. the late-replicating fraction of DNA present as condensed "chromocentres" in interphase nuclei, remain obscure. This is despite widespread application of the recently discovered fluorescence and denaturation-reannealing techniques which indicate the location of heterochromatin bands in metaphase chromosomes (Caspersson *et al.*, 1968; Pardue and Gall, 1970).

In general, heterochromatin continues to be associated with developmental effects of the quantitative type. However, great diversity occurs not only in the nature of its effects but also in the nature of heterochromatin itself.

For example, Vosa (1970) demonstrated that there exist in plants at least four types of heterochromatin, characterised variously by enhanced or reduced quinacrine fluorescence and by positive or negative sensitivity to cold. The various responses of heterochromatin to denaturation-reannealing treatment followed by Giemsa staining add further complexity to the situation, such that in *Allium flavum* alone there exist four types of heterochromatin as characterised by their various responses to fluorescence and Giemsa staining (Vosa, 1973).

Of late, it has proved possible to obtain new evidence on the functions of heterochromatin by using the new techniques to identify the location of heterochromatin in interphase nuclei. Thus Mogford (1977) demonstrated that heterochromatin is involved in an end-to-end fusion of chromosomes in onion

interphase nuclei, with the various consequences this implies for gene transcription and meiotic pairing.

The present study was designed to investigate the relationship between heterochromatin and nucleolar synthesis in the interphase nuclei of *Encephalartos* species.

MATERIAL AND METHODS

Investigations were performed on growing root tips from seedling specimens of *Encephalartos lehemanni* Ecklon ex Lehm. and *E. caffer* Miq.

Nucleoli were studied by means of phase-contrast illumination using visible light, while heterochromatin was revealed using the combined denaturation-reannealing-fluorescence technique described previously (Mogford, 1977). The relationship between heterochromatin and the nucleoli was observed by means of simultaneous reflected-light fluorescence and transmitted-light phase contrast, using a Zeiss fluorescence microscope.



FIG. 1.

Metaphase chromosomes of *E. lehemanni*, prepared as indicated in text. Arrows indicate positions of heterochromatin; note the heterochromatic (and heteromorphic) satellites of the nucleolar organising chromosomes, marked by the larger arrows. X1349.



FIG. 2.
E. lehemanni, X1349.

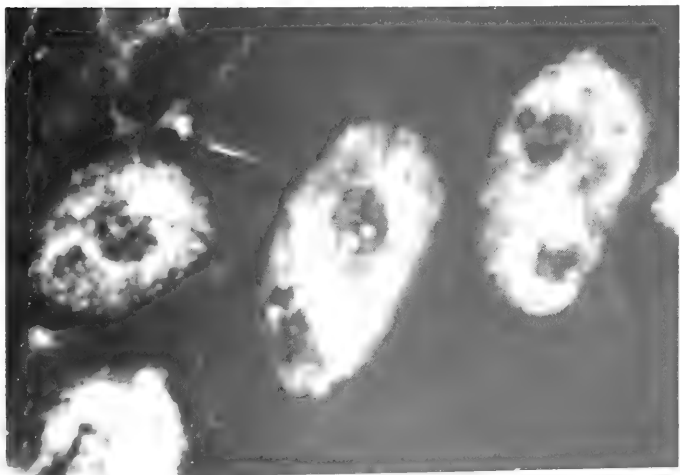


FIG. 3.
E. caffer, X843.

FIGS 2 & 3

Interphase nuclei of *Encephalartos*, showing relationship between heterochromatin and nucleoli. Photographed using combined fluorescence and phase contrast as described in text.

RESULTS

Heterochromatin in *E. lehemanni* was found to be present on the nucleolar chromosome pair, principally in the vicinity of the nucleolar organisers, and also on certain of the other chromosomes (Fig. 1).

In both species, the heterochromatin visible during interphase was found to be strongly localised at positions along the borders of the nucleoli (Figs 2 & 3). It was assumed that this heterochromatin was that of the nucleolar chromosome pair, though the possibility that other heterochromatin was involved as well could not be ruled out since fusion of chromocentres during interphase is a common phenomenon.

DISCUSSION

The occurrence of heterochromatin in the vicinity of the nucleolar organisers, even in the quantities recorded in the present observations, is not by itself unusual. What is unusual is the extremely conspicuous association of heterochromatin with nucleoli in the interphase nuclei. This association in cycads may to some extent be inferred by conventional staining (Marchant, 1968), but is demonstrated with particular clarity by the present technique.

The relationship raises again the possible involvement of heterochromatin in nucleolar synthesis, for the consistency of the association is greater than that which might be expected simply from the location of heterochromatin in the vicinity of the secondary constrictions.

Brown (1966) suggested that heterochromatin in the vicinity of the nucleolar organiser might serve as an inert region of chromosome, separating off the intense ribosomal RNA synthetic activity of the nucleolus organiser itself from the activities of the remainder of the chromosome.

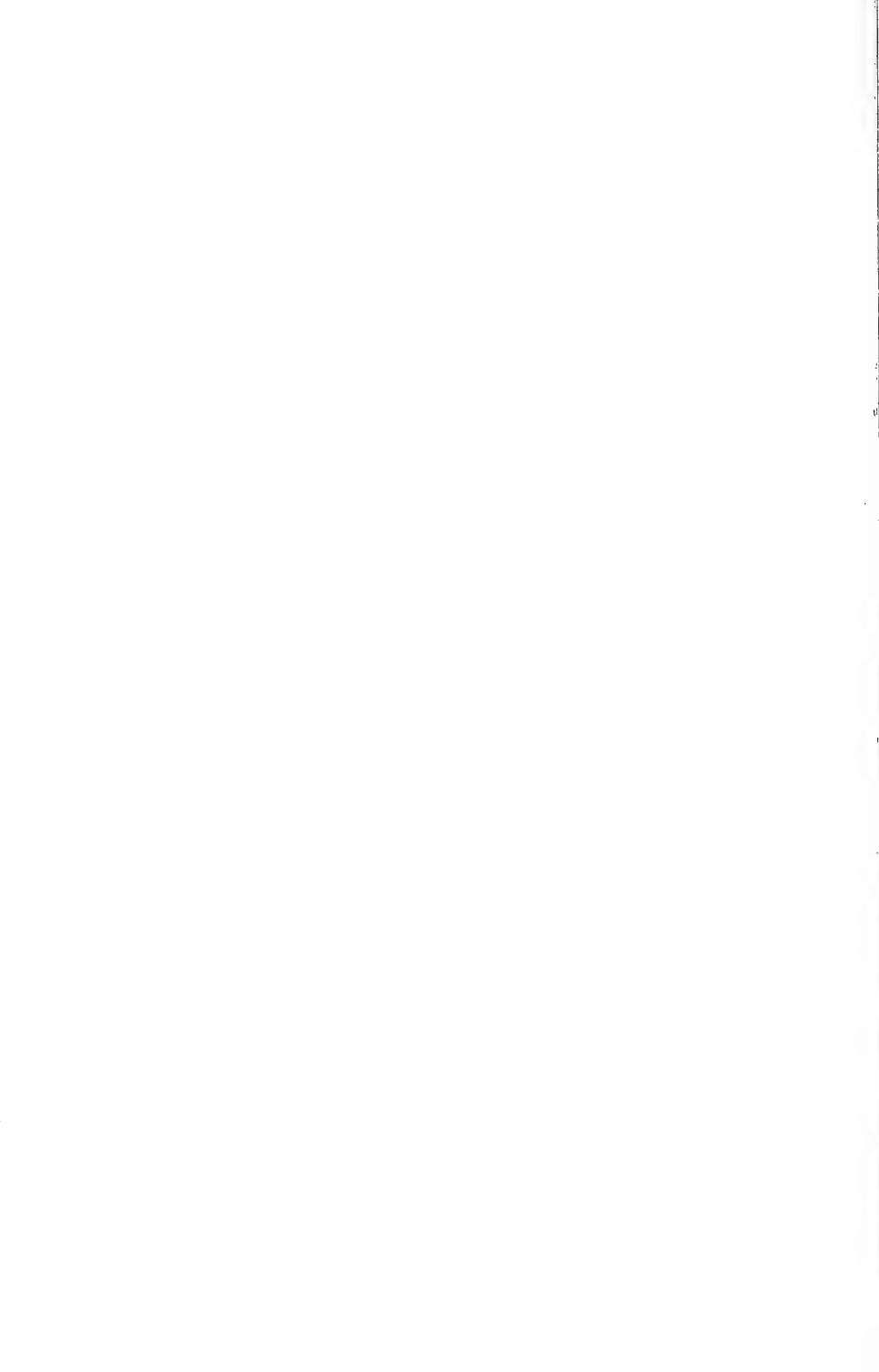
An alternative possibility is that heterochromatin itself might be involved in nucleolar synthesis. Certainly, such an intense and specific role would be consistent with the high degree of base repetition which modern studies indicate as characterising heterochromatin. Such repetition, indeed, would be consistent with the general quantitative action of heterochromatin. The difficulty here is that DNA in the heterochromatic state is normally assumed to be non-synthetic, though as a generalisation this is now less tenable in view of recent evidence for a differential amplification of certain heterochromatic DNA in both plant and animal species (Schweizer and Nagl, 1976). Of particular relevance is the observation of a differential amplification of nucleolus-associated heterochromatin in both the beetle *Dytiscus marginalis* and the cricket *Acheta domestica* (John and Lewis, 1975). The possibility of a synthetic role cannot therefore be excluded.

ACKNOWLEDGMENT

May I thank Mr Cameron of the Grahamstown Botanical Garden for the loan of cycad seedlings.

REFERENCES

- BROWN, S. W., 1966. Heterochromatin. *Science, N.Y.* **151**: 417-425.
- CASPERSSON, T., FARBER, S., FOLEY, G. E., KUDYNOWSKI, J., MODEST, E. J., SIMONSSON, E., WAGH, U. and ZECH, L., 1968. Chemical differentiation along metaphase chromosomes. *Expl. Cell Res.* **49**: 214-222.
- JOHN, B. and LEWIS, K. R., 1975. *Chromosome hierarchy*. Oxford University Press.
- MARCHANT, C. J., 1968. Chromosome patterns and nuclear phenomena in the cycad families *Stangeriaceae* and *Zamiaceae*. *Chromosoma* **24**: 100-134.
- MOGFORD, D. J., 1977. Chromosome associations in onion root tip nuclei. *Jl S. Afr. Bot.* **43**: 97-102.
- PARDUE, M. L., and GALL, J. C., 1970. Chromosome localisation of mouse satellite DNA. *Science* **168**: 1356-1358.
- SCHWEIZER, D., and NAGL, W., 1976. Heterochromatin diversity in *Cymbidium*, and its relationship to differential DNA replication. *Expl. Cell Res.* **98**: 411-423.
- VOSA, C. G., 1970. Heterochromatin recognition with fluorochromes. *Chromosoma* **30**: 366-372.
- VOSA, C. G., 1973. The enhanced and reduced fluorescence bands and their relationship to the Giemsa patterns in *Allium flavum*. *Nobel Symposium* **23**: 156-158.



TWO NEW SPECIES AND A NEW COMBINATION IN THE GENUS *KALANCHOE*

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ABSTRACT

K. neglecta Toelken, *K. rubinea* Toelken and the new combination *K. luciae* Hamet subsp. *montana* (Compt.) Toelken are published.

UITTREKSEL

TWEE NUWE SPESIES EN 'N NUWE KOMBINASIE IN DIE GENUS *KALANCHOE*

K. neglecta Toelken, *K. rubinea* Toelken en die nuwe kombinasie *K. luciae* Hamet subsp. *montana* (Compt.) Toelken word gepubliseer.

Raymont Hamet worked for many years on the taxonomy of the genus *Kalanchoe*. He was, however, unable to complete a revised version of his early monograph published in 1907, and a number of names used by him on determinavit labels were not validly published. The need thus arose to re-evaluate these taxa and to validly publish them in order to avoid confusion.

Kalanchoe luciae Hamet subsp. *luciae*

K. luciae Hamet in Bull. Herb. Boissier ser. 2, 8: 256 (1908); Hamet et Marnier-Lapostolle, Gen. *Kalanchoe* au Jard. Bot. Les Cedres 91, figs 112-114 (1964). Type: Transvaal, Spelonken, *Junod s.n.* (G, holo.).

Plants often up to 1,5 m high and glabrous. *Leaves* obovate to orbicular rarely oblanceolate. *Sepals* 2,5-4,5 mm long, glabrous. *Squamae* usually square to transversely oblong.

— subsp. *montana* (Compt.) Toelken, comb. nov.

K. montana Compt. in Jl S. Afr. Bot. 33: 295 (1967). Type: Swaziland, near Devil's Bridge, *Compton 29 471* (NBG, holo.!).

Plants rarely more than 1 m high and usually hairy. *Leaves* narrowly oblanceolate to rarely obovate. *Sepals* 5-6,5(-7) mm long, with scattered hairs. *Squamae* oblong.

The subsp. *montana* is usually found associated with rock outcrops in sour grassveld while the typical subspecies grows on rocky upper slopes of hills in bushveld.

Kalanchoe neglecta Toelken, sp. nov. a *K. rotundifolia* Haw. thyrsos corymbosus densus et foliis profunde cordatis; a *K. hirta* Harv. lobis angustis corollae et foliis profunde cordatis differt.

Herbae perennes ramis erectis, per florescentia usque ad 1 m altis et 15 mm in diametro, glabrae. *Folia* petiolata, glabra; petioli 20–50(–80) mm longi, leviter sulcati supra; laminae ovatae 35–80(–130) mm longae, profunde cordatae vel peltatae, integrae vel leviter sinuatae, patelliformes vel planae, virides. *Inflorescentia* thyrsus corymbosus floribus multis in dichasiis densis. *Calyx* lobis anguste lanceolatis, (1,5–)2–3 mm longus, glaber, viridis. *Corolla* glabra, tubo paene tereti 6–7,5 mm longo; lobi anguste lanceolati et aceres, 2,5–3,5 mm longi, vitellini vel aurantiaci. *Stamina* verticillis duobus longitudine inaequali, antheris flavis 0,5–0,6 mm longis et quoque appendicula terminali indistincta. *Squamae* lineares 1,6–2,5 × 0,2–0,3 mm, gradatim decrescentes ad apices, vix crassae, pallide flavae. *Carpella* stylis brevibus tenuibus et stigmatibus terminalibus; ovarium ovulis multis quoque c. 0,5 mm longis.

Type: Natal, Sordwana Bay, Vahrmeijer & Tölken 835 (PRE, holo.!).

Perennial herbs with erect branches up to 1 m high and 15 mm in diameter when in flower, glabrous. *Leaves* petiolate, glabrous; petioles 20–50(–80) mm long, slightly grooved above; lamina ovate 35–80(–130) mm long, deeply cordate or peltate, entire or slightly sinuate, flat to patelliform, green. *Inflorescence* a corymbose thyrse with many flowers arranged in dense dichasia. *Calyx* with lobes narrowly lanceolate, (1,5–)2–3 mm long, glabrous, green. *Corolla* glabrous, with tube almost terete and 6–7,5 mm long; lobes narrowly lanceolate and sharply pointed, 2,5–3,5 mm long, yellow to orange. *Stamens* in two whorls of unequal length, with yellow anthers 0,5–0,6 mm long and each with an indistinct terminal appendage. *Squamae* linear, 1,6–2,5 × 0,2–0,3 mm, gradually tapering towards the apices, scarcely fleshy, pale yellow. *Carpels* with short thin styles and terminal stigmata; ovary with many ovules each c. 0,5 mm long.

Growing in small groups but never common, on sandy soil in north-eastern Natal.

Hamet used the name *K. rotundifolia* var. *peltata* on determinavit labels but this name cannot be used at species level because of *K. peltata* Baill.

Kalanchoe rubinea Toelken, sp. nov. a *K. longiflora* Schltr. ex J. M. Wood ramibus teretibus et foliis plicatis recurvatis rubinescentibus differt.

K. longiflora var. *coccinea* Marnier-Lapostolle ex Jacobsen, Handb. Succ. Pl. 2: 652, fig 866 (1960); Sukk. Lex. 253, t. 105,1 (1970), non rite publicatum.

Herbae perennes ramibus decumbentibus teretibus sed inflorescentiis erectis in flore usque ad 1 m altis. *Folia* quoque plerumque petiolo, glabra; petiolus (8–)15–30(–45) mm longus, paene teres sed sulco non profundo supra; lamina late

elliptica vel ovata, 50–70(–100) mm longa, 40–60(–80) mm lata, cordata in foliis infernis sed plus minusve cuneata in foliis supernis, longitudinaliter plicata et plus minusve recurva, lobis quoque 1–3(4) dentibus obtusis, viridis vel atrorubinea. *Inflorescentia* thyrsus corymbosis dichasiis multis. *Calyx* lobis triangulari-lanceolatis, (1,5–)2–3(–5) mm longus, glaber, flavo-viridis. *Corolla* glabra, tubo 9–14(–15) mm longo et quadrangulati; lobi late ovati vel paene orbiculares et mucronibus terminalibus, 2,5–4 mm longi, minute papilloso, flavi. *Stamina* verticillis duobus longitudine inaequati, antheris flavis 0,7–1 mm longis et quoque appendicula terminali gracili. *Squamae* lineari-lanceolatae, 1,6–4 × 0,8–1,1 mm, apicibus gradatim constrictis, vix succulentae, pallide flavae. *Carpella* stylis papilloso gracilibus et stigmatibus terminalibus prominentibus; ovarium 50–80 ovulis quoque 0,6–0,8 mm longis.

Type: Transvaal, Soutpansberg, *Galpin 14 934* (PRE, holo.!).

Perennials with decumbent branches but erect inflorescences up to 1 m high when in flower, with terete branches. *Leaves* usually petiolate, glabrous; petiole (8–) 15–30(–45) mm long, almost terete but with indistinct groove above; lamina broadly elliptic to ovate, 50–70(–100) mm long, 40–60(–80) mm broad, cordate on lower leaves, cuneate in upper leaves, folded length-wise and more or less recurved, with lobes each with 1–3(–4) obtuse teeth, green to deep ruby red. *Inflorescence* a corymbose thyrses with many dichasia. *Calyx* with lobes triangular-lanceolate (1,5–)2–3(–5) mm long, glabrous, yellowish-green. *Corolla* glabrous, with tube 9–13(–15) mm long and quadrangular; lobes broadly ovate to almost orbicular and with terminal mucro, 2,5–4 mm long, minutely papillose, yellow. *Stamens* in two whorls of unequal length, with broad yellow anthers 0,7–1 mm long and each with a slender terminal appendage. *Squamae* linear-lanceolate, 1,6–4 × 0,8–1,1 mm, gradually tapering towards the apex, scarcely fleshy, pale yellow. *Carpels* with slender papillose style and prominent terminal stigmas, ovary with 50–80 ovules each 0,6–0,8 mm long.

K. rubinea occurs along the Eastern Transvaal escarpment from eastern Swaziland to the Soutpansberg.

This species, which is widely used in horticulture, was always confused with *K. longiflora*, an endemic species of central Natal.

BOOK REVIEWS

GLOSSARY OF GENETICS AND CYTOGENETICS, CLASSICAL AND MOLECULAR, by R. Rieger, A. Michaelis and M. M. Green, with pp. 647. Fourth completely revised edition. ISBN 3-540-07668-9. Berlin-Heidelberg-New York, Springer-Verlag, 1976. US \$14.80.

The new Glossary is an impressively efficient looking book with some 3 500 entries and 1 700 references. The print is clear and readable and the text is liberally interspersed with clear schematic line drawings. Arrows (\rightarrow) indicate cross-references. Its size, $20 \times 14 \times 3$ cm, makes it easy to handle and, although the review copy has a soft cloth cover, it is strongly bound and should last well.

The third edition (the first English edition) has been in our department for many years and I have consulted it frequently. However, on being asked to review the new edition I realized that consulting and reviewing this kind of book are quite different. One usually consults a glossary for the meaning of terms in fields of the subject with which one is not familiar. On the other hand, in assessing the value of the book as reviewer, one is restricted to the assessment of terms in one's own specialized field. My impression of this book after having looked at it as a reviewer in the field of quantitative genetics is one of disappointment with the quality and the accuracy of the text. I present the following examples in support of this criticism.

- p. 24 *allozygote* (McKusick, 1973)—“a genetic compound, i.e., heterozygous for different alleles”. This definition is incomplete and misleading. Crow and Kimura (1970) follow the notation of Cotterman in designating an individual whose two homologous genes are identical by descent as autozygous. If the two alleles are of independent origin, the individual is said to be allozygous. Allozygotes can therefore be either homozygotes or heterozygotes. The term autozygote is not included in the Glossary. This is a pity because it could have been used to avoid the muddle in describing the effects of inbreeding on page 290. In passing, McKusick (1973) is not included in the bibliography.

- p. 53 *breeding value*. In terms of the definition given here it is incorrect to omit the factor of 2.

- p. 111 *coancestry*. Falconer (1960) has been misquoted. The definition should refer to the degree of relationship by descent, not to the degree of identity by descent of the two parents. Also it is incorrect to say that coancestry may be used in place of the coefficient of relationship.

- p. 112 *coefficients of coancestry, kinship and parentage* are given on the same page. They refer respectively to individuals I & L, A & B, and X & Y and different words are used to describe these synonyms. It is an apt example of what Crow and Kimura (1970) have described as a “bewildering plethora of alternative names”.

- p. 112 *coefficient of relationship*—“the probability that two individuals have inherited a certain gene from a common ancestor, or the proportion of all their allelic genes that have been inherited from common ancestors”. This merely adds to the general bewilderment and the situation is certainly not clarified by the definition of genetic relationship given on page 243.

- p. 124 *correlated response* (Wigan and Mather, 1942)—“a change in one character (phenotype) occurring as an incidental consequence of selection for a seemingly independent character”. This represents one of two major schools of thought. In this “linkage school” the correlated response has low predictability. The “pleiotropy school” uses genetic correlation to predict correlated response. Omitting the latter is inexcusable irrespective of one’s own affiliation. It is interesting to note that genetic correlation is not listed in its own right but is included with character (p. 74) and phenotype (p. 417). In each case both pleiotropy and linkage are given as possible causes of genetic correlation. It is interesting to note also that the following statement is made on page 494 under the listing of selection: “Artificial selection applied to one character almost always leads to changes in others (“correlated response”)”. Again, in passing, Wigan and Mather (1942) is not included in the bibliography.
- p. 252 *genetic value*—“the phenotypic value an individual would have if there were no environmental variation and no dominance effects”. This is a very strange definition. It is cross-referenced to genetic variance (p. 254) where it is said that, “Genetic variance can be divided into two components: 1. g.v. resulting from differences between homozygotes (additive g.v.); 2. g.v. resulting from specific effects of various alleles in heterozygotes (dominance variance)” and that, “Dominance here refers to deviations of the heterozygote from the two homozygotes”. When presented with this kind of draft by a student I find myself suggesting gently but firmly that he re-consult his references, that he give more thought to the matter and that he rewrite the section concerned.
- p. 256 *genotype-environment interaction*. Although no reference is given it is fairly clear that Falconer’s (1960) provisional clearance of the decks of complications when discussing the additivity of variance components has been rather ineptly summarized. No further attempt has apparently been made by the compilers to understand the concept.
- p. 267 *heritability*. It is stated *inter alia* that, “Heritability is a measure of the amount of genetic variability, excluding that expressed by heterozygotes . . .”. This muddle arises I think from the assumption, evidenced in the Glossary in the definitions of genetic value and genetic variance, that pure additivity of gene action is a prerequisite for additive genetic variance.
- p. 290 *inbreeding coefficient* (Wright, 1929). It is stated that, “If the frequencies of two alleles (A and a) in a population are p_A and q_a and the inbreeding coefficient is F , then the chance that an individual will be genotypically AA is p_F The chance that the two alleles at that locus will not be identical by descent is $1-F$ ”. This is incorrect. The expected frequency of AA autozygotes is p_F while the expected frequency of AA allozygotes is $p^2 (1-F)$. In passing, the reference to Wright (1929) is inappropriate and the page number given in the bibliography is incorrect.
- p. 339 *maternal effect*—“any nonlasting effect of the maternal genotype or phenotype on the immediate offspring.” I do not think a maternal effect is necessarily of limited duration nor do I think that a definition of maternal effect without mentioning maternal environment is adequate. I think “immediate” is an inappropriate choice of word in so far that it is used with a specific meaning by both Penrose (1954) and Robson (1955) in describing maternal effects.
- p. 445 *progeny selection and progeny test*. The definitions are not precise and there is no mention of or cross-reference to breeding value. The ingredients for predicting selection response are given without saying why they should be considered.

p. 496 *selection response*. After nearly three pages devoted to various forms of natural and artificial selection including definitions of selection coefficients, pressures, differentials and limits, selection response reads, in full: "the gain in liability due to selection which is a function of the heritability of liability, assuming that genotype-environment interactions are absent. If A is the mean liability of affected individuals (those in the tail of the general population distribution), and R the mean of their offspring, then the realized gain in liability is $R-A$ ". This to say the least is inappropriate since no prior reference or cross-reference is made to threshold characters. A few words concerning the predictability of selection response could surely have been included?

In fairness to the compilers I feel I must repeat that I am not competent to judge the text as a whole. At the same time I do not think they are competent in the field of quantitative genetics and it is a pity they did not include in their team one who is.

J. S. ALLAN

KRYPTOGAMEN. BLAUALGEN, ALGEN, PILZE, FLECHTEN, by K. Esser, with pp. 573 + xvi, illus. Berlin-Heidelberg-New York, Springer-Verlag, 1976. DM58.00

Even though this book is bound in a soft cover it is a sturdy volume of convenient size (16.5×24 cm). The text appears to have been typed and reproduced photographically on good quality white glossy paper and is clear and easy to read. Two type sizes have been employed, the smaller one instead of italics, without creating an unbalanced effect.

Except for occasional spelling errors there is little fault to be found with the accuracy of the text. It is, however, also important to remember that taxonomic systems and arrangements are subject to personal interpretation, and a reader may be surprised at finding some taxa included in unexpected categories. Some taxonomic names which have been rejected for some time are again used in this book. By and large, however, the taxonomic framework followed is acceptably up to date.

There is an abundance of illustrative material. The drawings are well done and clear, as are the diagrams. The photographs are on the whole well chosen but are unfortunately rather soft, with few definite blacks or whites. The overall impression is thus of rather dull illustrations which lack the brilliance they could have had. A number of photographs have also been retouched to accentuate desired areas. This could mislead a student into believing that the detail he is looking for on a microscope preparation is more obvious than it in actual fact is.

There are comparatively few references in the text. Those that are used are given as footnotes and not combined into a single list. This does mean that to find a reference which has previously been quoted can prove extremely troublesome. There are, however, comprehensive lists of suggested references, grouped under a variety of headings, at the back of the book. These are extremely useful to student readers, but do not compensate for the frustrations referred to above.

The index is comprehensive and detailed and there is also a list of taxa, an essential in a book of this nature.

The book is aimed primarily at teachers of cryptogamic botany, would be very useful for postgraduate students at Honours level but is not suitable for the unaided undergraduate. The research worker will not find much in it. Certain sections would not apply to South African conditions but on the whole the information given could be applicable. However, as the book is written in the German language, its local appeal is likely to be extremely limited. Despite its attractions the text does not offer so much that the non-German speaking reader will find it worth his while to translate it.

This book is not a textbook in the normally accepted sense. It is intended to give a brief review of the basic facts about the blue-green algae, the algae, the fungi and the lichens, followed by a section on technology where fixatives, media, preservatives, sampling and

handling techniques, etc. are given. The bulk of the volume (approximately 480 pages) is then devoted to detailed discussions of individual organisms representative of the various taxonomic subdivisions.

Techniques for finding and isolating organisms are followed by life cycle diagrams, recommendations on cultivation and examination and, in most cases, photographs or drawings of the various stages. Suggestions as to possible genetic experiments or other demonstrations are also plentiful.

Whereas the book is thus extremely useful to the lecturer planning a course in cryptogamic botany, the average student will find it difficult to obtain a coherent picture of the organismic groups covered without extensive additional reading or assistance. As the book is written for European conditions the South African lecturer will find some of the suggested experimental organisms or programmes inappropriate.

There is, furthermore, a very important gap in the treatment of the fungi, and that is a totally inadequate discussion of the Fungi Imperfecti. They are a large and successful group of fungi and there are dynamic developments which are not even mentioned. Only eight pages are devoted to the imperfect fungi and more than three of these to the dermatophytes.

The book ends with a useful section, admittedly less so for South African readers, containing addresses of culture collections and suppliers of teaching films.

Despite its shortcomings, a highly interesting book.

K. T. VAN WARMELO

THE REPRODUCTIVE POTENTIAL OF *ERICA JUNONIA* BOLUS: MEGASPOROGENESIS AND MEGAGAMETOGENESIS

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ABSTRACT

The embryological study of *Erica junonia* forms part of an investigation into the inadequate propagation of the species. The ovule is anatropous, unitegmic and tenuinucellate. The archesporial cell functions directly as the megaspore mother cell. Embryo-sac development is monosporic and conforms to the Polygonum-type of the Supra Homotypic Category. Starch grains are present in the integument and an endothelium lines the chalazal region. Observations thus far suggest no restrictive effect on the reproduction of *E. junonia*.

UITTREKSEL

DIE VOORTPLANTINGSPOTENSIAAL VAN *ERICA JUNONIA* BOLUS: MEGASPOROGENESE EN MEGAGAMETOGENESE

Die embriologiese studie van *Erica junonia* maak 'n deel uit van 'n ondersoek na die gebrekkige voortplanting van die spesies. Die saadknop is anatroop, tenuinussellêr en besit 'n enkele integument. Die argesporiale sel funksioneer direk as die megaspoormoedersel. Embriosakontwikkeling is monospories en geskied volgens die Polygonum tipe van die Supra-Homotipiese Kategorie. Styselkorrels is teenwoordig in die selle van die integument en die chalazagedeelte van die embriosak word deur 'n endotelium omhul. Hierdie studie van megasporogenese en megagametogenese toon geen beperkings op die voortplanting van *E. junonia*.

INTRODUCTION

The large-flowered variety of *Erica junonia*, reputed to be the most magnificent of the ericas, occurs only on a single mountain peak in the Cold Bokkeveld north of Ceres (Baker & Oliver, 1967). It flowers from November to January. Germination of seeds has been unsuccessful, but the species can be propagated by means of cuttings. However, these vegetatively propagated plants do not set seed.

The inadequate propagation of *E. junonia* led to its being declared an endangered species by the C.S.I.R.'s Working Group on Rare and Endangered plant species. This study forms part of an attempt to pinpoint the locus which blocks the pathway to successful propagation.

MATERIAL AND METHODS

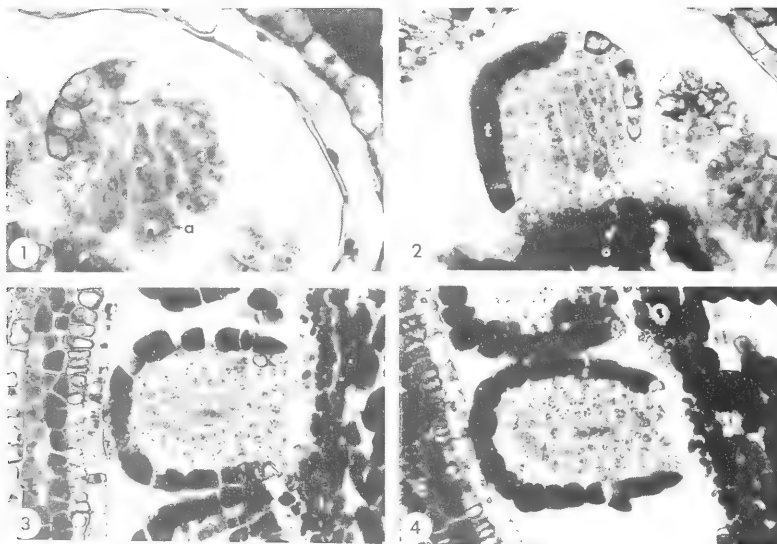
Flowers of *E. junonia* were collected from their natural habitat near Ceres and fixed in formalin-acetic acid-alcohol. Dehydration was carried out in an ethyl alcohol/tertiary butyl alcohol series and the material was embedded in Carowax

(melting point 55 °C). Ovaries were sectioned on a rotary microtome at 10 μm and stained with safranin and fast green (Sass, 1958).

RESULTS AND DISCUSSION

Megasporogenesis

Numerous ovules are contained in each of the four locules. Their placentation is axile. Each ovule is anatropous (Fig. 2) and has a single, large integument (Figs 1 & 2). According to Davis (1966) these characteristics are reasonably constant for the Ericaceae. When the embryo sac reaches maturity the epidermis of the integument becomes completely tanniferous.



Megasporogenesis in *E. junonia*

FIG. 1

Young ovule showing archesporial cell
(a = archesporial cell, i = integument) ($\times 600$)

FIG. 2

Megaspore mother cell. Note the absence of nucellus
(i = integument, mc = megaspore mother cell, t = tanniferous cells) ($\times 380$)

FIG. 3

Heterotypic division of meiosis ($\times 380$)

FIG. 4

Tetrad of megaspores in which three micropylar ones are degenerating
(functional megaspore arrowed) ($\times 380$)

At a very early stage in ovule development a single hypodermal cell becomes prominent. This is the archesporial cell (Fig. 1) and it functions directly as the megaspore mother cell. There are no parietal layers between the nucellar epidermis and the megaspore mother cell and so the ovule can be classified as tenuinucellate. According to Maheshwari (1950) there are two types of tenuinucellate ovules, namely, those in which the integument primordia are situated near the apex of the nucellus and a second type in which the integument originates at the base of the nucellus. In *E. junonia* the latter type occurs.

The nucellus is only three cell layers wide and is ephemeral. Its degeneration occurs rapidly during the development of the megaspore mother cell. This cell enlarges (Fig. 2) at the expense of the nucellus so that at maturity it is bordered completely by the integument only.

Fig. 3 shows the metaphase stage of the heterotypic division during meiosis of the megaspore mother cell. After completion of the homotypic division, a linear tetrad of megaspores is formed (Fig. 4).

Megagametogenesis

Of these four megaspores only the chalazal one persists (Fig. 5) and functions as the embryo-sac initial. The development of the embryo-sac is therefore monosporic. The nucleus of the functional megaspore is centrally situated and until this stage the embryo-sac exhibits no polarity.

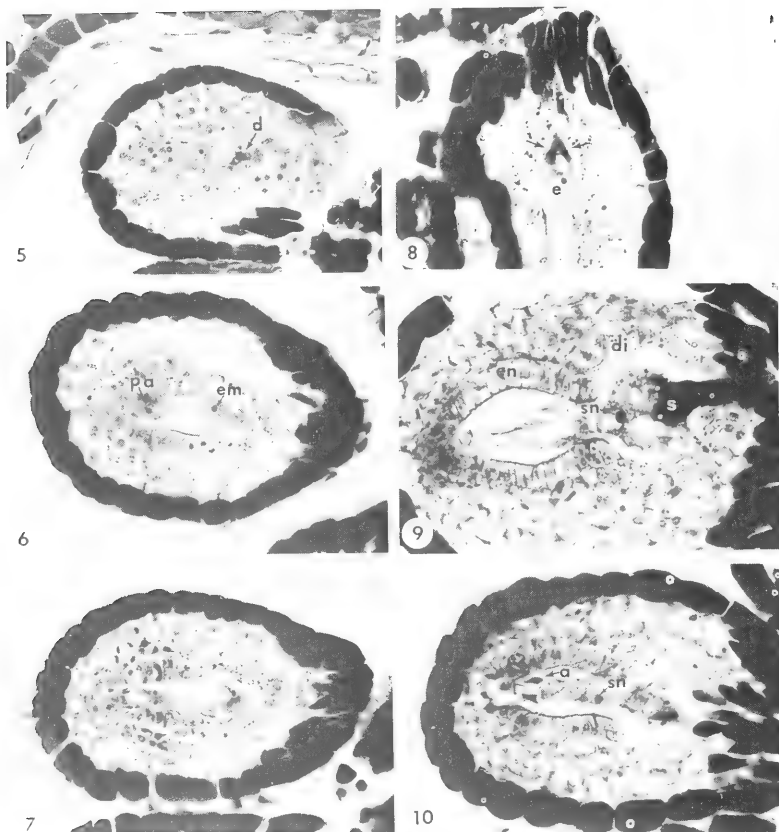
Division of this nucleus results in the formation of a two-nucleate embryo-sac (Fig. 6). One of these nuclei, the egg-apparatus mother nucleus, migrates towards the micropyle while the other nucleus, the primary antipodal nucleus, moves to the chalazal end. Because polarity of the embryo-sac is established at this stage of development, the embryo-sac of *E. junonia* conforms to the Supra Homotypic Category (Swamy & Krishnamurthy, 1975).

Once polarity has been achieved, the embryo-sac enters the elaboration phase. Each of the two nuclei divides, producing a four-nucleate embryo-sac (Fig. 7) and following yet another division, the embryo-sac contains eight nuclei.

These eight nuclei now undergo organization into the constituents of a mature embryo-sac. At the micropylar end the tripartite egg apparatus consists of an egg cell flanked by two synergids which soon become densely cytoplasmic (Fig. 8). The micropylar region of the embryo-sac becomes spherical and enlarges at the expense of the integumentary tissue, the cells of which contain numerous starch grains. Davis (1966) reports the occurrence of starch grains in the embryo-sacs of many ericaceous species.

A well-differentiated endothelium lines the chalazal region of the embryo-sac (Figs 9 & 10)—the function of this endothelium is not clear. Opposite the point where the endothelium layer terminates the secondary embryo-sac nucleus occurs (Fig. 9).

Three antipodal cells are found in the chalazal region of the embryo-sac. Each



Megagametogenesis in *E. junonia*

FIG. 5

Uni-nucleate embryo-sac (d = degenerating megaspores) ($\times 380$)

FIG. 6

Two-nucleate embryo-sac

(em = egg apparatus mother cell, pa = primary antipodal nucleus) ($\times 380$)

FIG. 7

Elaboration phase showing four-nucleate embryo-sac ($\times 380$)

FIG. 8

Egg apparatus (e = egg cell, synergids arrowed) ($\times 380$)

FIG. 9

Mature embryo-sac

(di = degenerating integument cells, containing starch grains, en = endothelium, s = synergid, sn = secondary embryo-sac nucleus) ($\times 380$)

FIG. 10

Mature embryo-sac (a = antipodal cells, sn = secondary embryo-sac nucleus) ($\times 380$)

cell has a definite cell wall (Fig. 10). The antipodals are derived from a single primary antipodal nucleus and therefore the embryo-sac of *E. junonia* is of the Polygonum type (Swamy & Krishnamurthy, 1975).

This study shows that the processes involved in the attainment of haploidy, the establishment of polarity and the maturation of the embryo-sac appear to take place normally. Up to this stage, therefore, there is no restriction on the propagation potential of *E. junonia*.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Mr J. Winter who was responsible for the collection of plant material.

REFERENCES

- BAKER, H. A. and OLIVER, E. G. H., 1967. *Ericas in Southern Africa*. Cape Town: Purnell & Sons.
- DAVIS, Gwenda L., 1966. *Systematic embryology of the Angiosperms*. New York: John Wiley & Sons, Inc.
- MAHESHWARI, P., 1950. *An introduction to the embryology of Angiosperms*. New York: McGraw-Hill Book Company, Inc.
- SASS, J. E., 1958. *Botanical microtechnique*. Iowa: Iowa State University Press.
- SWAMY, B. G. L. and KRISHNAMURTHY, K. V., 1975. Embryo-sac ontogenies in Angiosperms—an elucidation. *Phytomorphology* **25**: 12–18.

EFFECT OF VARIOUS TREATMENTS ON GERMINATION OF DORMANT SEEDS OF *STRELITZIA REGINAE* AIT.

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ABSTRACT

The effects of a wide variety of dormancy-breaking treatments on the germination of *S. reginae* seeds were investigated. Germination was improved after treating the seeds with thiourea, various mercaptans, ascorbic acid and ethrel; by incubation in elevated oxygen concentrations; and by removal of the tissues overlying the embryo in the seed. Treatments which did not improve germination included incubation in elevated carbon dioxide concentrations, leaching with water, various storage conditions, and treatment with urea, indoleacetic acid, gibberellic acid, kinetin, various oxidizing agents, and respiratory inhibitors. Low temperatures had a decidedly harmful effect on both dry and imbibed seeds.

UITTREKSEL

INVLOED VAN VERSKILLENDE BEHANDELINGS OP DIE ONTKIEMING VAN *STRELITZIA REGINAE* AIT. SADE WAT IN 'N RUSTOESTAND VERKEER

Die invloed van 'n verskeidenheid rusbeëindigende behandelings op die ontkieming van *S. reginae* sade is ondersoek. Ontkieming is verbeter nadat sade behandel is met tio-ureum, verskeie merkaptane, askorbiensuur en ethrel; deur inkubasie in verhoogde suurstofkonsentrasies sowel as na verwydering van die weefsels wat die embrio in die saad oordek. Behandelings wat ontkieming nie verbeter het nie is: inkubasie in verhoogde koolstofdiksiedkonsentrasies, loging van die sade met water, verskeie opbergings toestande, asook saadbehandeling met ureum, indoolasynsuur, gibberelliensuur, kinetien, verskeie oksideermiddels en respiratoriese inhibeerders. Lae temperature het 'n besliste nadelige uitwerking gehad op beide droë en geïmbibeerde sade.

INTRODUCTION

Seeds of the acaulescent species of *Strelitzia* exhibit a condition of innate, relative dormancy (van de Venter & Small, 1974). Evidence has been presented that an inhibitor may be involved in this phenomenon (van de Venter & Small, 1975) but this does not preclude the possibility of contributions by other factors since dormancy can be the result of a combination of factors (Villiers, 1972).

In an attempt to obtain more information on the mechanisms controlling dormancy of *S. reginae* seeds, the preliminary approach of determining the effect of various well-known dormancy-breaking treatments on these seeds was used. A treatment which will promote the germination of dormant seeds can be expected to have some bearing on the operative mechanism and it was envisaged that these experiments would provide guidelines for further research.

MATERIAL AND METHODS

Seeds of *S. reginae*, harvested from various plants in the East London area, were used. The seeds were pooled and stored under ambient conditions in the laboratory (ca. 20 °C). All experiments were conducted on seeds that were less than a year old.

The seeds were sterilized and germinated in petri dishes as previously described (van de Venter & Small, 1974). Due to limited quantity, only 25 seeds per dish represented one replicate. The number of replicates varied between four and eight, depending on the particular experiment.

Unless otherwise mentioned, only scarified seeds were used. Incubation proceeded in the dark at 25 ± 0.5 °C and counts were made after 14 days. The seeds were scarified with emery paper to expose a few square millimeters of endosperm.

Treatment of seeds with various chemicals was accomplished by immersing them (after surface-sterilization) for 48 hours in sterile solutions of these compounds, prior to incubation in petri dishes.

In experiments involving treatments with oxygen and carbon dioxide, seeds were incubated in sterile, 130 ml-capacity conical flasks containing 4 ml sterile, distilled water. Oxygen and carbon dioxide concentrations were adjusted to required values by injecting specific volumes of these gases through the vaccine caps sealing the flasks. Where an atmosphere of pure oxygen was required, flasks were flushed with this gas for three minutes.

Arcsin transformation of germination percentages was carried out before statistical tests were applied and lowest significant difference (LSD) values calculated according to the ω -procedure of Tukey (Steel & Torrie, 1960).

RESULTS

Effect of light and scarification

Scarified and unscarified seeds were subjected to light and dark treatments in a 2×2 factorial design. Light was supplied from cool white fluorescent tubes at an intensity of ca. 12 000 lux. Petri dishes of the dark treatment were wrapped in a single layer of aluminium foil.

The results of this experiment (Table 1) show that scarification did not improve germination to a significant extent. However, this treatment improved water absorption by the seeds (Fig. 1). Light had a harmful effect on the germination of unscarified seeds.

Effect of thiourea, urea, various mercaptans and ascorbate

Seeds were soaked in different concentrations of thiourea, urea, reduced glutathione, L(+) cysteine, 2,3-dimercapto-1-propanol (BAL) and L(+) ascorbic acid. All of these compounds, with the exception of urea, promoted germination at certain concentrations (see Table 2).

TABLE 1

Germination percentage of scarified and unscarified seeds of *S. reginae* in light and dark (Arcsin transformed values in brackets)

	Light	Dark	Mean
Scarified seeds	31 (33,49)	25 (29,21)	28 (31,35)
Unscarified seeds	13 (20,20)	30 (31,96)	21 (26,08)
Mean	22 (26,85)	27 (30,58)	
Effects:	F Values:	LSD	
Light	1,85	—	
Scarification	3,68	—	
Light \times Scarification	8,50**	(10,55)	

Effect of growth substances

Seeds were soaked in concentration series of gibberellic acid (GA_3 ; 0,1–1 000 ppm), indoleacetic acid (1–1 000 ppm), kinetin (3–48 ppm) and ethrel (1 000–5 000 ppm active ingredient). With the exception of ethrel, no significant promotion of germination was found. The optimal concentration of ethrel was

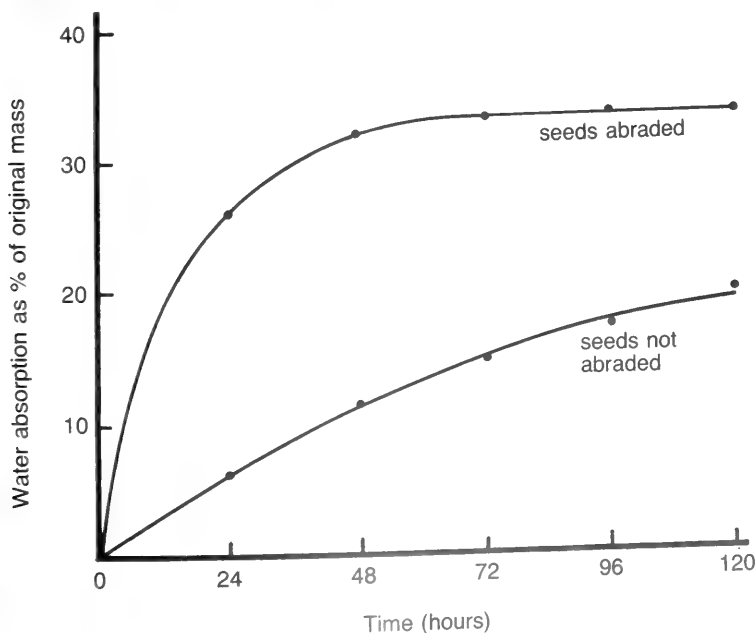


FIG. 1

Effect of abrasion on water absorption by *S. reginae* seeds.

TABLE 2
Germination† of *S. reginae* seeds treated with various concentrations of thiourea, urea, various mercaptans and ascorbic acid

Thiourea			Urea		Glutathione			Cysteine		BAL		Ascorbic acid		
ppm	Concen- tration	Trans- formed %	Concen- tration	Trans- formed %	Concen- tration	Trans- formed %	Concen- tration	Trans- formed %	Concen- tration	Trans- formed %	Concen- tration	ppm	M × 5,7	Trans- formed %
0	0	20,96	0	27,91	0	29,65	0	33,69	0	16,73	0	0	0	30,25
5	10 ⁻⁵	16,72	10 ⁻⁵	20,97	0,1	31,47	10 ⁻⁴	33,69	10 ⁻⁵	11,67	0,1	10 ⁻⁷	10 ⁻⁷	27,00
50	10 ⁻⁴	34,02	10 ⁻⁴	20,97	1	35,23	10 ⁻³	51,43	10 ⁻⁴	21,62	1	10 ⁻⁶	10 ⁻⁶	27,36
500	10 ⁻³	48,20	10 ⁻³	21,71	10	33,63	10 ⁻²	54,41	10 ⁻³	36,23	10	10 ⁻⁵	10 ⁻⁵	31,35
5 000	10 ⁻²	44,20	10 ⁻²	23,89	100	45,70	10 ⁻¹	51,29	10 ⁻²	26,42	100	10 ⁻⁴	10 ⁻⁴	37,24
50 000	10 ⁻¹	0,0	10 ⁻¹	0,0	1 000	51,29					1 000	10 ⁻³	10 ⁻³	58,76

F values: 75,31**

LSD: 9,03

15,50**

11,18

8,90**

12,67

22,56**

9,87

7,34**

15,21

34,95**

9,13

† Arcsin transformation of germination percentage

found to be 2 000 ppm. At this concentration 65 % of the seeds germinated as compared to 27 % in the control.

Effect of carbon dioxide and oxygen

The treatments applied in these experiments are listed in Table 3 and are expressed in terms of volumes of CO₂ and O₂ in the flasks as a percentage of the total gas volume.

TABLE 3

Effect of different carbon dioxide and oxygen concentrations on germination of *S. reginae* seeds (Arcsin transformed values in brackets)

Carbon dioxide		Oxygen	
Concentration %	Germination %	Concentration %	Germination %
0 (KOH in centre well)	3	20,0 (air)	2 (4,66)
		24,1	2 (4,66)
0,03 (air)	3	27,9	3 (8,51)
2,5	2	34,7	10 (18,09)
4,8	2	100,0	42 (40,24)
9,3	2		
17,4	2		

F value: 29,74**

LSD: (11,48)

The results of these experiments should be interpreted with caution as the seeds in the different treatments were exposed to different gas pressures. Respiratory activity of the seeds could also have changed the original gas composition.

In spite of these technical restrictions it seems valid to conclude from the results in Table 3 that whereas elevated CO₂ concentrations elicited no response, elevated O₂ concentrations had a stimulatory effect on germination. Poor germination in the control and CO₂ treatments was probably the result of limiting oxygen in the sealed flasks.

The beneficial effect of oxygen was confirmed in a subsequent experiment using larger flasks (600 ml capacity). Incubation in 100 % oxygen resulted in 64 % of the seeds germinating within one week. Seeds in control flasks that were not sealed, but stoppered with cotton-wool, showed a germination of only 11 %.

Mechanical restriction of embryo growth

Scarified seeds were allowed to imbibe water for two days after which the tissues covering the embryo in the proximal region of the seed were excised. As sterile conditions were difficult to maintain during this so-called chipping operation, the seeds were not sterilized. The seeds were incubated in quartz sand kept moist with daily applications of tap water. After three weeks, only eight per cent

of the seeds in the control treatment had germinated in comparison with the 53 % germination attained by chipped seeds.

Effect of different storage conditions

Air-dry seeds were kept in cotton-wool stoppered flasks for four weeks at room temperature (ca. 20 °C), 40 °C, 50 °C as well as in sealed 600 ml flasks (at ca. 20 °C) flushed weekly with pure oxygen. A stratification treatment (imbibed seeds kept at 4 °C for four weeks) was also included.

None of the treatments resulted in an increased germination. Both storage at 50 °C and stratification proved to be decidedly deleterious, depressing germination by 21 and 34 %, respectively, relative to the room-temperature control.

A subsequent observation on air-dry seeds that had been stored for 10 months at 4 °C, showed that this treatment decreased germination by 18 % in comparison to laboratory-stored seeds.

Effect of oxidizing agents and respiratory inhibitors

Treatments consisting of concentration series of KNO_2 (1–1 000 ppm), KNO_3 (1–10 000 ppm), H_2O_2 (2–8M with different exposure times), methylene blue (10^{-4} – 10^{-2} M) and KCN (10^{-5} – 10^{-2} M) failed to show any stimulatory effect on germination. Germination was improved by a concentration of 10^{-4} M sodium azide, but the effect was not statistically significant.

Effect of leaching

Although there is evidence for the presence of a water-soluble inhibitor in the seeds of *S. reginae* (van de Venter & Small, 1975), leaching of scarified seeds in running tap water for six days failed to improve germination.

DISCUSSION

Judging from the variety of treatments which have been found to improve germination of *S. reginae* seeds, their dormant condition seems to be a complex phenomenon with possibly more than a single causative factor. It would be premature to speculate on possible control mechanisms at this stage but, nevertheless, the results have implicated the involvement of various factors which might be investigated more fully.

Thiourea, a well-known dormancy-breaking agent (Mayer & Poljakoff-Mayber, 1963) was found to improve germination of *S. reginae* seeds. The fact that various mercaptans, in contrast to urea, were able to improve germination, suggests that the stimulatory effect of thiourea resulted from the tendency of this compound to form a thio-imido tautomer which occurs in equilibrium with the normal form of thiourea (Toole, Hendricks, Borthwick & Toole, 1956; Garrard & Biggs, 1966). That the reductive capacity of these compounds is involved, was suggested by the positive results with ascorbate.

Paradoxically, the promotive effects of increased oxygen concentrations on germination indicate the necessity of an oxidation reaction for the termination of dormancy. Alternatively this result could simply be indicative of a permeability barrier in the seed coat. The magnitude of the response to oxygen points to a major involvement of this gas in the termination of dormancy and indicates that this factor should be further investigated.

Roberts (1969, 1973) proposed that, in the seeds of certain species, cytochrome oxidase competes for available oxygen with a dormancy-breaking reaction. He postulated that operation of the pentose phosphate pathway is a prerequisite for the termination of dormancy. The seeds of *S. reginae*, although responding positively to oxygen and thiourea, failed to do so to electron acceptors, respiratory inhibitors, storage in elevated oxygen tension, and stratification. These results suggest that the mechanism, as proposed by Roberts, would not serve as a hypothetical model for dormancy in *Strelitzia* seeds.

The view that dormancy is essentially under hormonal control, that is, inhibitors interacting with growth promoters, has been expounded by authors such as Mayer (1960) and Amen (1968). Control of this nature in the case of *Strelitzia* is a distinct possibility and merits further attention. Evidence for the presence of an inhibitor has been presented (van de Venter & Small, 1975) and the involvement of ethylene in the termination of dormancy (as implied by the effect of ethrel) is indicated by these results.

Possible correlations between the factors already mentioned and the mechanical restriction of embryo growth by the seed coat are not clear at this stage. Mechanical restriction by the seed coat is known to be involved in the seed dormancy of various species (Randolph & Cox, 1943; Chen & Thimann, 1964, 1966; Chen, 1968).

The significance of the light x scarification interaction is also vague. Mayer & Poljakoff-Mayber (1963) have reported that seed-coat damage can alter the response of seeds to light.

ACKNOWLEDGEMENTS

Financial assistance from the Council for Scientific and Industrial Research and the University of Port Elizabeth is acknowledged.

REFERENCES

- AMEN, R. D., 1968. A model of seed dormancy. *Bot. Rev.* **34**: 1-31.
CHEN, S. S. C., 1968. Germination of light-inhibited seeds of *Nemophila insignis*. *Am. J. Bot.* **55**: 1177-1183.
CHEN, S. S. C. and THIMANN, K. V., 1964. Studies on the germination of light-inhibited seeds of *Phacelia tanacetifolia*. *Israel Jnl Bot.* **13**: 57-73.
CHEN, S. S. C. and THIMANN, K. V., 1966. Nature of seed dormancy in *Phacelia tanacetifolia*. *Science, N.Y.* **153**: 1537-1538.
GARRARD, L. A. and BIGGS, R. H., 1966. Thioamide-induced germination of seeds of *Prunus persica*. *Phytochem.* **5**: 103-110.

- MAYER, A. M., 1960. Germination research at the Hebrew University Jerusalem, Israel—A review. *Indian J. Pl. Physiol.* **3**: 13–23.
- MAYER, A. M. and POLJAKOFF-MAYBER, A., 1963. *The germination of seeds*. London: Pergamon Press.
- RANDOLPH, L. F. and COX, L. G., 1943. Factors influencing the germination of *Iris* seed and the relation of inhibiting substances to embryo dormancy. *Proc. Am. Soc. hort. Sci.* **43**: 284–300.
- ROBERTS, E. H., 1969. Seed dormancy and oxidation processes. In: *Dormancy and survival*: 161–192. Cambridge: University Press.
- ROBERTS, E. H., 1973. Oxidative processes and the control of seed germination. In: W. Heydecker (ed.), *Seed ecology*. Chap. 2. London: Butterworths.
- STEEL, R. G. D. and TORRIE, J. H., 1960. *Principles and procedures of statistics*. 1st ed. New York: McGraw-Hill Book Co.
- TOOLE, E. H., HENDRICKS, S. B., BORTHWICK, H. A. and TOOLE, V. K., 1956. Physiology of seed germination. *A. Rev. Pl. Physiol.* **7**: 299–324.
- VAN DE VENTER, H. A. and SMALL, J. G. C., 1974. Dormancy in seeds of *Strelitzia* Ait. *S. Afr. J. Sci.* **70**: 216–217.
- VAN DE VENTER, H. A. and SMALL, J. G. C., 1975. Evidence for the presence of a germination inhibitor in seeds of *Strelitzia* Ait. *Jl S. Afr. Bot.* **41**(4): 211–223.
- VILLIERS, T. A., 1972. Seed dormancy. In: T. T. Kozlowski (ed.), *Seed biology*. Vol. II. Chap. 3. New York: Academic Press.

CENTROMERIC HETEROCHROMATIN IN *LACHENALIA TRICOLOR* (L.) THUNB.

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ABSTRACT

The South African *Lachenalia tricolor* is notable for possessing large amounts of heterochromatin. The heterochromatin is centromeric in position, and may be revealed either by direct quinacrine staining or by denaturation-reannealing treatments. The significance of this is discussed relative to the general occurrence and adaptive significance of this type of chromatin.

UITTREKSEL

SENTROMERIESE HETEROCHROMATIEN IN *LACHENALIA TRICOLOR* (L.) THUNB.

Die Suid-Afrikaanse *Lachenalia tricolor* word deur groot hoeveelhede heterochromatien gekenmerk. Die heterochromatien is sentromeries in posisie en kan deur direkte beitsing met kinakrien of met denaturasie-hervoeging behandeling aangedui word. Die betekenis hiervan word bespreek met betrekking tot die algemene voorkoms en aanpasbaarheidsbetekenis van dié soort chromatien.

INTRODUCTION

Heterochromatin, i.e. the late-replicating fraction of DNA present as condensed "chromocentres" in resting nuclei, has been the subject of renewed interest over recent years. This has followed the discovery that the positions of heterochromatin bands in metaphase chromosomes may be revealed by their differential fluorescence in ultraviolet light following treatment with certain fluorochromes (Caspersson *et al.*, 1968), and by their differential staining with Giemsa or orcein following denaturation-reannealing treatments (Pardue and Gall, 1970; Vosa, 1973a). The latter method derives from the highly repetitive base constitution of heterochromatin, which results in its reannealing more completely than the remainder. These techniques are of much wider applicability than the older method based on the understaining of heterochromatin in chromosomes exposed to low temperature (Darlington and La Cour, 1940), for only certain types of heterochromatin show such cold sensitivity.

The new techniques have greatly increased the number of plant species in which heterochromatin is known to occur. Heterochromatin has been demonstrated, for example, in *Vicia* (Vosa and Marchi, 1972), *Hepatica*, *Anemone* (Marks and Schweizer, 1974), and *Encephalartos* (Mogford, 1978). Heterochro-

matin has been found to be particularly frequent among the cultivated cereals such as *Triticum* (Gill and Kimber, 1974), *Secale* and *Hordeum* (Vosa, 1974, 1976a), and also among the Liliaceae such as in *Scilla*, *Tulbaghia* and *Allium* (Vosa, 1973 b,c, 1976 b,c).

In many such cases it has become clear that the number and position of heterochromatin bands constitutes a character as important in the study of species relationships as are chromosome number and morphology themselves. Equally, however, among plant species the occurrence of heterochromatin in large amounts remains exceptional. The discovery of large quantities of heterochromatin in the South African *Lachenalia tricolor*, to be described in the present work, was therefore considered of particular interest.

MATERIAL AND METHODS

Investigations were performed on plants from a clonal population of *Lachenalia tricolor* growing in the garden of the Department of Plant Sciences, Rhodes University, and on plants of the variety *quadricolor* obtained from a commercial source. Voucher specimens of these varieties are deposited in the Rhodes University Herbarium as accessions number 23793 and 23794 respectively.

In all cases rapidly growing root tips were used, pretreated with 0.1 % colchicine for four hours and fixed in 3:1 ethanol: glacial acetic acid for 8-16 hours.

For studies of chromosome number and morphology, root tips were hydrolysed in 1N HCl at 60 °C for 6 minutes, incubated in Feulgen reagent for 90 minutes at room temperature, and squashed in acetic orcein.

For the recognition of heterochromatin, three techniques were used: quinacrine fluorescence (Caspersson *et al.*, 1968); denaturation-reannealing followed by staining with the benzimidazole derivative Hoechst 33258 (Vosa, 1976b); and denaturation-reannealing followed by Giemsa staining (Pardue and Gall, 1970).

The procedures were as follows. For all methods except quinacrine staining, the root tips were first hydrolysed in 0.2N HCl at 60 °C for 2.5 minutes. For all treatments, the root tips were then squashed in 45 % acetic acid under an albumenised coverslip, the coverslip then being floated off in absolute alcohol and air dried. Subsequent steps were conducted on the cells adhering to the coverslip.

For quinacrine fluorescence, the preparations were stained in 0.5 % quinacrine dihydrochloride (Gurr's Atebrine) in absolute alcohol for 5 minutes at room temperature. Excess quinacrine was rinsed off in absolute alcohol, and the preparation air-dried, following which the preparation was mounted in 50 % glycerine and viewed using a Zeiss fluorescence microscope with exciter filter BG12 and barrier filters 50 plus 53.

For the denaturation-reannealing treatments, the preparations after the first air-drying were denatured by immersion for 6 minutes in a saturated solution of barium hydroxide at room temperature. The preparations were then rinsed thoroughly in running distilled water, and reannealed by immersion in 2 × saline

sodium citrate buffer for 30 minutes at 60 °C. The preparations were then either stained in 0.02 % alcoholic Hoechst 33258, with this and the subsequent steps as for quinacrine staining, or else were immersed overnight in a 0.5 % aqueous solution of Giemsa buffered to pH 6.8. The latter preparations were then air dried and mounted permanently in Gurr's Depex.

RESULTS

The diploid chromosome number was found to be 14, as previously determined by Spelta (1972). All the chromosomes were very small, ranging in size from 1.1 to 2.6 μ . The karyotype was markedly asymmetric, being composed of one, relatively large, telocentric pair (pair 1, Fig. 1), one large and two small acrocentric pairs (nos. 3, 4 and 5), and one large and two small metacentric pairs (nos. 2, 6 and 7).

The techniques for heterochromatin recognition indicated that heterochromatin was present on all the chromosomes, and was exclusively centromeric in position. The heterochromatin was uniform in its staining response, showing positive stainability in all three techniques.

Of the various techniques, quinacrine staining was the least satisfactory, due to the rapid fading of fluorescence. In contrast, denaturation-reannealing followed by Hoechst staining gave a brilliant, stable fluorescence which clearly indicated the location of heterochromatin despite the small size of the chromosomes. The results with Giemsa were comparable but less distinct.

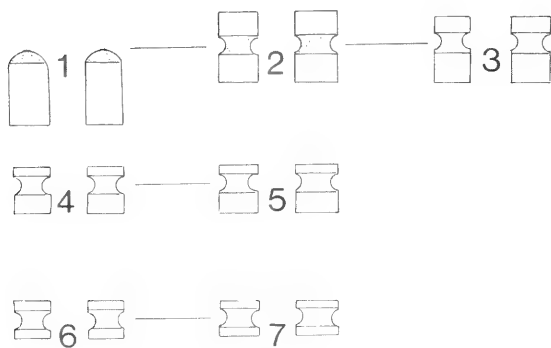
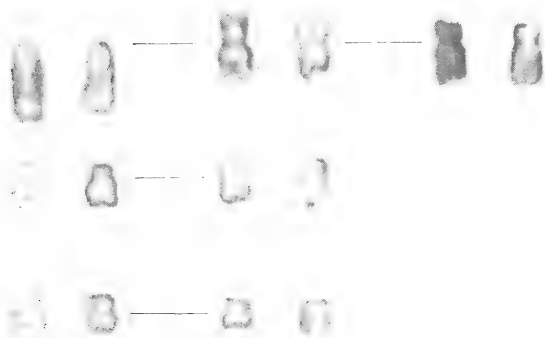
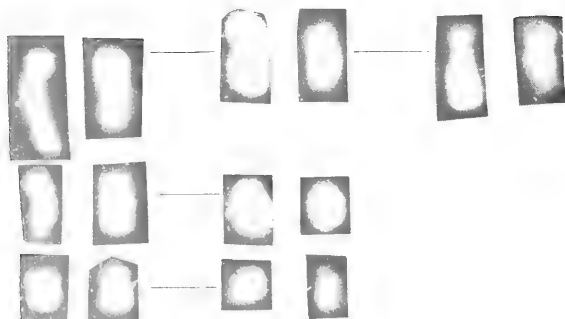
Chromosome number, morphology, and the position of heterochromatin were all constant throughout both cultivars studied.

DISCUSSION

The present work emphasises further the widespread occurrence of heterochromatin among the Liliaceae, the significance of which is not yet clear. Stebbins (1971) regarded heterochromatin as particularly characteristic of highly specialised species—a viewpoint which, though fully supported by the recent demonstration of heterochromatin in *Encephalartos* (Mogford, 1978), is nevertheless difficult to apply to individual species such as the present without adequate comparative studies within the groups concerned.

From the purely functional viewpoint, it is of interest that all the heterochromatin in the present species is centromeric in position. Such is the case even with the telocentric chromosomes, which morphologically are highly dissimilar to the remainder. Terminal and intercalary bands, so frequent in the other cases cited above, are not in evidence.

Moreover, no differences occurred between chromosomes in the staining responses of the heterochromatin. This contrasts with the situation which exists, for example, in *Allium flavum*, in which different heterochromatin bands show all

ABC

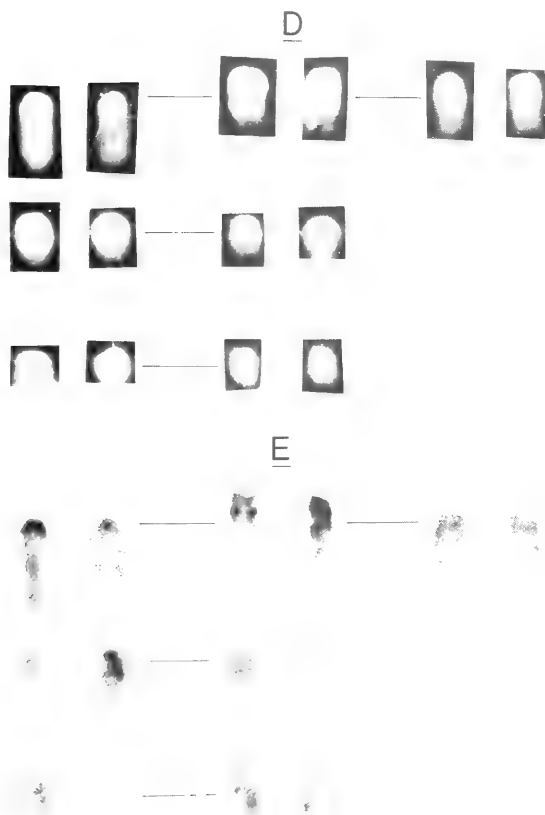


FIG. 1.
The karyotype of *Lachenalia tricolor*

A, Idiogram. Stippling indicates position of heterochromatin; B, Feulgen/Acetic orcein staining, phase contrast illumination; C, Quinacrine, fluorescence; D, Barium/SSC/Hoechst, fluorescence; E, Barium/SSC/Giemsa, brightfield illumination.
All $\times 1\ 500$.

four combinations of enhanced or reduced quinacrine fluorescence, and positive or negative stainability with Giemsa (Vosa, 1973d).

The constant position and stainability of heterochromatin in this species suggests that such has a uniform and specific role. Brown (1966) suggested that heterochromatin in the vicinity of the centromeres, and also that in the vicinity of the nucleolar organisers, might serve to separate off the highly specialised activities of these regions from those of the remainder of the chromosome.

Nowadays, however, other possibilities may be cited. Heterochromatin, for instance, is now known to be characterised by a highly repetitive base constitution, which suggests that nucleolar organiser heterochromatin might be involved in nucleolar synthesis (Mogford, 1978); while centromeric heterochromatin might well be involved in chromosome organisation during interphase, or meiotic pairing (Mogford, 1977). Further work is necessary to examine these possibilities.

REFERENCES

- BROWN, S. W., 1966. Heterochromatin. *Science, N.Y.* **151**: 417-425.
- CASPERSSON, T., FARBER, S., FOLEY, G. E., KUDYNOWSKI, J., MODEST, E. J., SIMONSSON, E., WAGH, U. and ZECH, L., 1968. Chemical differentiation along metaphase chromosomes. *Expl Cell Res.* **49**: 214-222.
- DARLINGTON, C. D. and LA COUR, L. F., 1940. Nucleic acid starvation of chromosomes in *Trillium*. *J. Genet.* **40**: 185-211.
- GILL, B. S. and KIMBER, G., 1974. Giemsa banding and the evolution of wheat. *Proc. natn. Acad. Sci. U.S.A.* **71**: 4086-4090.
- MARKS, G. E. and SCHWEIZER, D., 1974. Giemsa banding: karyotype differences in some species of *Anemone* and *Hepatica nobilis*. *Chromosoma* **44**: 217-224.
- MOGFORD, D. J., 1977. Chromosome associations in onion root tip nuclei. *Jl S. Afr. Bot.* **43**: 97-102.
- MOGFORD, D. J., 1978. Nucleolar heterochromatin in *Encephalartos*. *Jl S. Afr. Bot.* **44**: 83-87.
- PARDUE, M. L., and GALL, J. C., 1970. Chromosome localisation of mouse satellite DNA. *Science* **168**: 1356-1358.
- SPETA, F., 1972. Entwicklungsgeschichte und Karyologie von Elaiosomen an Samen und Früchten. *Naturk. Jb. Stadt Linz*: 9-65.
- STEBBINS, G. L., 1971. *Chromosomal Evolution in Higher Plants*. London: Arnold.
- VOSA, C. G. and MARCHI, P., 1972. On the quinacrine and Giemsa patterns of the chromosomes of *Vicia faba*. *Gg. Bot. ital.* **106**: 151-159.
- VOSA, C. G., 1973a. Acetic-orcein, a new stain for the detection of constitutive heterochromatin in plant and animal chromosomes. *Expl Cell Res.* **79**: 463-465.
- VOSA, C. G., 1973b. Heterochromatin recognition and analysis of chromosome variation in *Scilla sibirica*. *Chromosoma* **43**: 269-278.
- VOSA, C. G., 1973c. Quinacrine fluorescence analysis of chromosome variation in the plant *Tulbaghia leucantha*. *Chromosomes Today* **4**: 345-349.
- VOSA, C. G., 1973d. The enhanced and reduced fluorescence bands and their relationship to the Giemsa patterns in *Allium flavum*. *Nobel Symposium* **23**: 156-158.

- VOSA, C. G., 1974. The basic karyotype of rye (*Secale cereale*) analysed with Giemsa and fluorescence methods. *Heredity, Lond.* **33**: 403-408.
- VOSA, C. G., 1976a. Chromosome banding patterns in cultivated and wild barleys (*Hordeum* spp.). *Heredity, Lond.* **37**: 395-403.
- VOSA, C. G., 1976b. Heterochromatic patterns in *Allium*. 1. The relationship between the species of the *cepa* group and its allies. *Heredity, Lond.* **36**: 383-392.
- VOSA, C. G., 1976c. Heterochromatic patterns in *Allium*. 2. Heterochromatin variation in species of the *paniculatum* group. *Chromosoma* **57**: 119-133.



THE PECULIAR LEAF TRICHOMES OF *PETREA VOLUBILIS* (VERBENACEAE)

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ABSTRACT

The structure of the unicellular, heavily silicified leaf trichomes of *P. volubilis* which account for the leaves' "sand paper" structure is clarified: the hairs consist of a disc-like base (in mature leaves frequently located in a shallow depression of the epidermis, and therefore usually not easily recognisable) and a conical, sharp tip in its centre (considered to be the whole hair by earlier workers). The development of these hairs is described, and observations are included about distribution and structure of the other types of non-glandular and glandular trichomes on the leaf blades of *P. volubilis*.

UITTREKSEL

DIE BESONDERSE BLAARTRIGONE VAN *PETREA VOLUBILIS* (VERBENACEAE)

Die struktuur van die eensellige, erg gesilisifieerde blaartrigone van *P. volubilis* wat die "skuurpapier" tekstuur van die blaar verklaar, word verduidelik: die hare het 'n skyfagtige basis (in volwasse blare dikwels in vlak holtes van die epidermis geleë en dus nie maklik uitkenbaar nie) en 'n koniese skerp punt in die middel (deur vorige werkers as die volledige haar beskou). Die ontwikkeling van hierdie hare word beskryf en waarnemings aangaande die verspreiding en struktuur van die ander tipes nie-klier- en kliertrigone op die blaarskyf van *P. volubilis* word ingesluit.

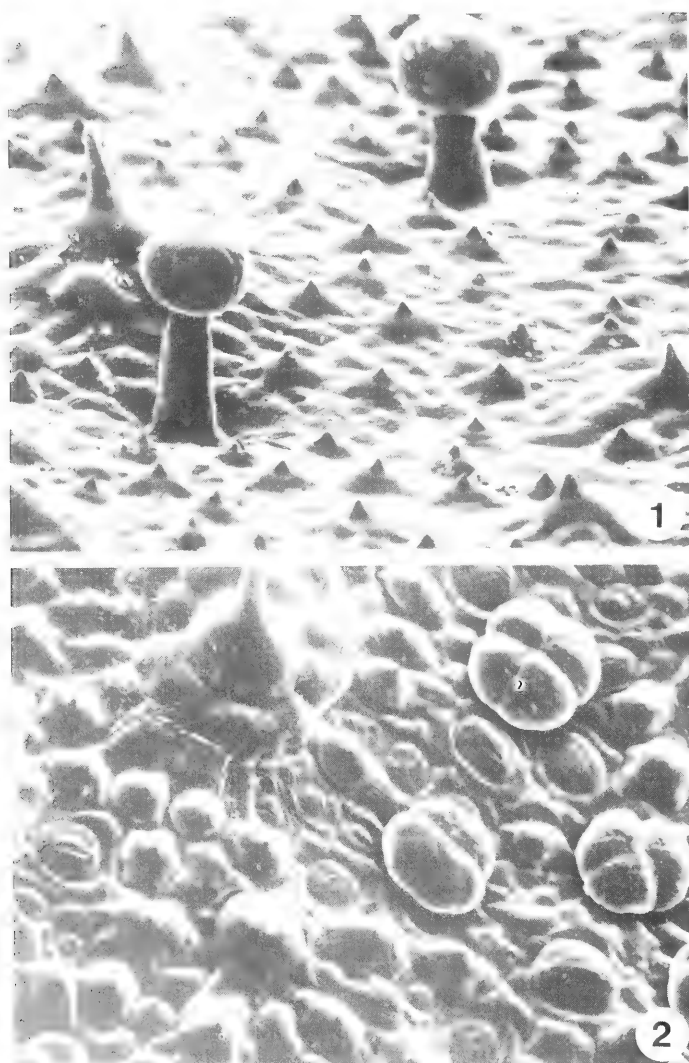
INTRODUCTION

Petrea volubilis L.¹, an attractive twining shrub indigenous to Central America and the West Indies and frequently grown in (sub)tropical gardens of the New and Old World, has evergreen, leathery leaves which are rough to the touch on both surfaces (they feel like sand paper if rubbed between two fingers). This roughness is due to the presence of peculiar hairs, about whose structure there exists a number of quite diverse and controversial interpretations:

Vesque (1885) writes about "peculiar conical *outgrowths* of the outer epidermal wall which are completely silicified". Solereder (1899) observed (in addition to glandular hairs which are not specific to *Petrea*, but characteristic for most Verbenaceae) "short, conical, silicified trichomes which are *embedded singly in the thickened outer wall* of the epidermis cells" and supports his description with

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¹ The spelling *Petraea* often found in horticultural books and journals is inaccurate; so is the frequently used author name Jacquin (Moldenke, 1938: 32).



FIGS 1 and 2.

Scanning electron micrographs of leaf blades of immature leaves. Fig. 1: adaxial surface, Fig. 2: abaxial surface. Figs 1 and 2: $\times 260$. Explanations in the text.

the drawing of raindrop-shaped hairs sunk in the epidermis wall. Metcalfe and Chalk (1950), without further comments, accept his diagnosis. Inamdar's (1969) description and drawing differ considerably from those of the earlier workers: according to him the trichomes are silicified, conical and unicellular (although he pictures a peculiar *three-tipped* hair with a number of "cavities" in the siliceous deposits), and are positioned *on top of* the epidermis, the base of each hair covering the area of numerous epidermal cells. Inamdar (*l.c.*), however, makes no reference to the conflicting results of the previous workers. Also Napp-Zinn (1973) fails to discuss these discrepancies, so that up to now the exact structure of these hairs is still unclear.

It, therefore, appeared worthwhile to re-examine in detail these trichomes, which apparently are specific to *P. volubilis* (and probably *Teijsmanniodendron* according to Metcalfe and Chalk, 1950) and unique in the Verbenaceae—a family characterised by a wide range of different hair forms (cf. Briquet, 1897; Solereder, 1899; Metcalfe and Chalk, 1950).

MATERIAL AND METHODS

Leaf material (usually 5 immature and 5 mature leaves) of *P. volubilis* growing in the gardens in and around Pietermaritzburg was collected and then immediately investigated under the light microscope (transverse sections by hand and epidermis peels) to ensure that the trichomes in question are a stable, always present feature of the species.

SEM investigations: Fresh leaf segments were coated with gold-palladium and viewed with a Hitachi SSM 2 at an accelerating voltage of 10 kV. It was not necessary to use the critical point drying method: no differences whatsoever were observed when pictures of fresh and critical point dried leaves were compared.

TEM investigations: The material was fixed for 2 h in 3% glutaraldehyde followed by 1 h in 1.0% OsO₄, both in 0.1 phosphate buffer (pH 7.0). After dehydration with graded ethanol the material was embedded in Epon 812. Ultrathin sections were post-stained with uranyl acetate and lead citrate. The electron micrographs were obtained with a Hitachi HU 11.

OBSERVATIONS

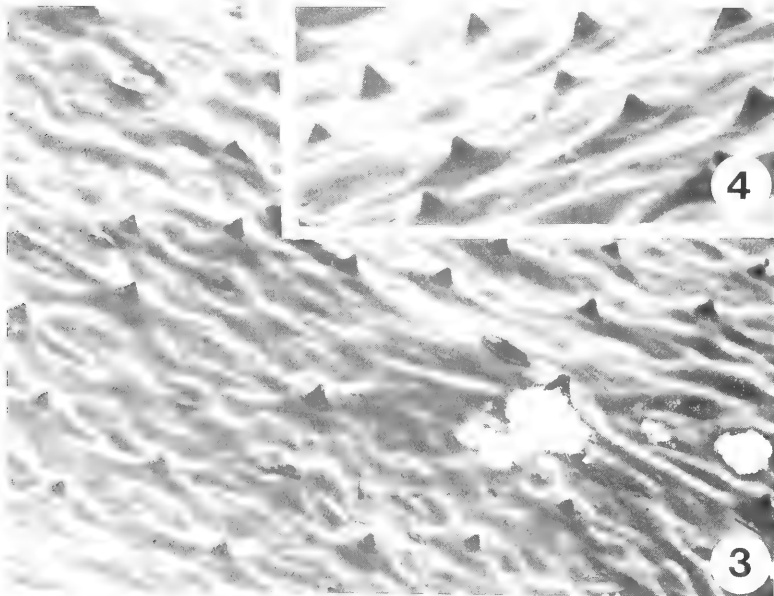
The following types of trichomes are found on the leaf blades of *P. volubilis*: (1) glandular hairs with a (A) short (one-celled) or (B) long stalk and a capitate gland consisting of two to several (6 to 9) radially arranged secretory cells (Figs 1 and 2), and (2) non-glandular trichomes in the form of (A) \pm long, unicellular hairs surrounded by a conspicuous "ring" of cells at the base (Fig. 2) and (B) "short, conical, unicellular hairs" (Solereder, *l.c.*) specific to the species. The occurrence of the various hair types is different on the ad- and abaxial surface of the blades, and also depends on the age of the leaf (Moldenke, 1938, already

mentions that the blades of mature leaves are very rough to the touch on both surfaces, whereas those of very immature ones are less conspicuously so).

The long-stalked glandular hairs are only found on the adaxial surface of very immature leaves, where they may occur in large numbers (and much more closely spaced than in the leaf portion shown in Fig. 1). They seem to completely vanish in old material (due to breaking or falling off?).

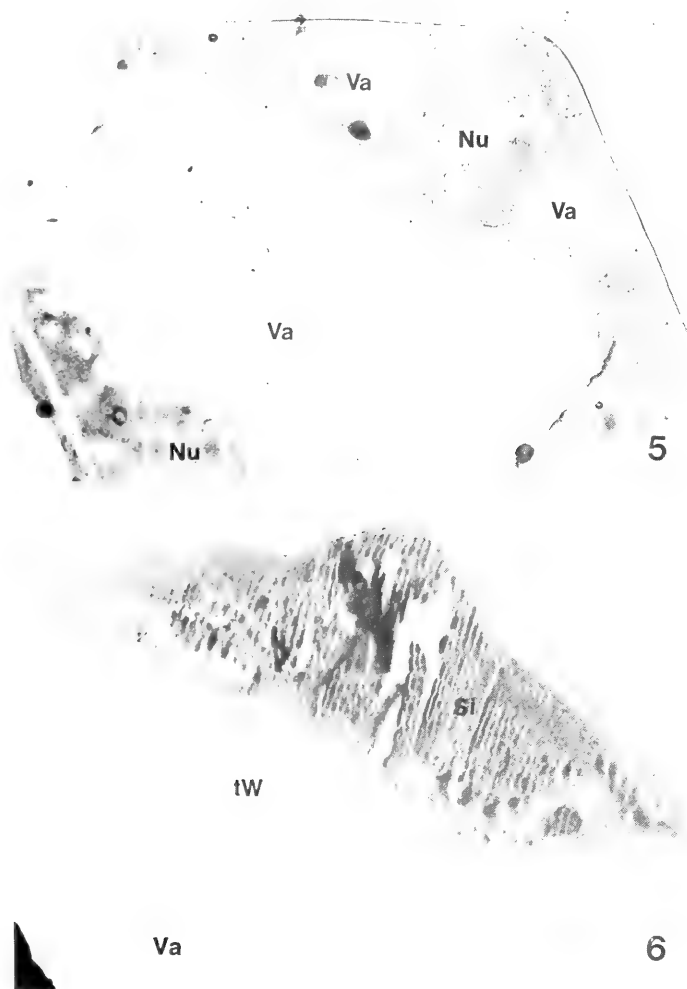
The short-stalked glands are very common on the abaxial surface of young and old leaves, but are often absent from the adaxial surface (if present, they never occur in large numbers and are sunk in crypts; their appearance is similar to that of sunken glandular hairs of *Avicennia marina*: Fahn and Shimony, 1977: Plate 1C). In mature leaves the number of secretory cells per gland is (6)8(9), in young and very young leaves it appears to be less (2-6; even recognisable in Fig. 2: the depressions on the glands correspond with the walls between two secretory cells). Obviously the fewer celled glandular trichomes represent younger stages of development (cf. Fahn and Shimony, 1977: Fig. 2J-N).

The very sparse, long, unicellular hairs (Figs 1 and 2) are found on the abaxial surface (particularly in young material) and (very seldom) on the upper epidermis, where they seem to completely disappear in mature leaves.



FIGS 3 and 4.

Scanning electron micrographs of adaxial surface of mature leaves. Fig. 3: $\times 260$ Fig. 4: $\times 400$. Explanations in the text.



FIGS 5 and 6.

Transmission electron micrographs of unicellular hairs. Fig. 5: off-median section of young, not yet silicified hairs (immature leaf). Fig. 6: close-to-median section of fully developed, heavily silicified hair (mature leaf); silicifications partially broken out. Nu: nucleus, Si: siliceous deposits, tW: thickened, layered cell wall, Va: vacuole. Figs 5 and 6: $\times 4200$.

The "short, conical hairs" sensu Solereder (*l.c.*) are densely distributed on both surfaces, although usually in much greater abundance on the adaxial surface (compare Figs 1 and 2). Although already present in immature leaves (Figs 1 and 2) they become particularly conspicuous on the adaxial surface of mature leaves (Figs 3 and 4), where they, in fact, look like Vesque's (*l.c.*) "peculiar outgrowths of the epidermis". Contrary to Solereder's (*l.c.*) interpretation, however, they are not raindrop-shaped and embedded in the outer epidermal wall: longitudinal sections prove that they actually sit singly on top of cells and, strictly speaking, are not conical, but consist of a flat, more or less disc-like base with a conical tip in its center, both of which are, in the mature stage, heavily silicified (Fig. 6). Solereder (*l.c.*) considered these tips, which are responsible for the "sand paper texture" of the plant's leaves, to be the whole hairs.

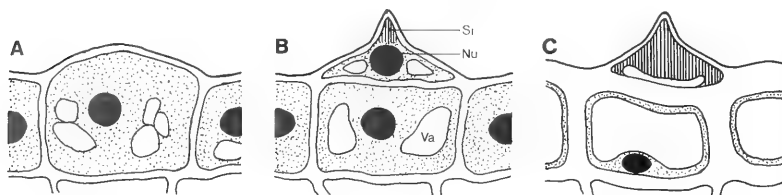


FIG. 7.

Schematic representation of three stages of development of the peculiar, unicellular trichomes. A: enlarged epidermis cell (hair initial), B: young hair with starting silicification, C: mature, heavily silicified hair. Nu: nucleus, Si: siliceous deposits, Va: vacuole. Further explanations in the text.

The development of these trichomes is as follows (Fig. 7): at an early stage of development of the leaf an epidermis cell increases in size and extends above the surrounding epidermal cells (Fig. 7A). This hair initially shows no significant differences from the neighbouring cells (cytoplasm dense, occupying almost the whole cell lumen; few, small vacuoles; large nucleus). After a periclinal and somewhat unequal division, hair cell and basal cell originate. The basal cell is usually larger than the hair cell and is generally not distinguishable from the neighbouring epidermis cells (Fig. 7B). The protoplast of the basal cell soon forms a layer against the cell wall so that a large central vacuole originates, while the cytoplasm still occupies most of the cell lumen of the hair cell (Fig. 5). It is presumed that, at this stage at the latest, the silicification of the conical tips of the hairs begins, although there is no concrete evidence for this (median sections of this stage of development always ripped out in the region of the tips indicating that it was already filled with difficult-to-cut siliceous deposits). As development continues the walls of the basal cells and the neighbouring epidermis cells thicken rapidly (the outer epidermal walls more than the inner ones) and become conspicuously layered (Fig. 6), and the hairs (whose walls do not thicken to that extent) become almost completely filled with siliceous deposits (Figs 6 and 7C).

At this stage (i.e. in mature leaves), the outer epidermal walls have become quite uneven, and the disc-like bases of the hairs often are somewhat obscured, since they are no longer—as in immature leaves—clearly raised above the level of the outer epidermal walls of the surrounding cells (compare Figs 1, 2 and 3, 4 and 6).

ACKNOWLEDGMENTS

The present investigation was carried out while at the Department of Botany, University of Natal, and I would like to thank Mrs M. G. Gilliland, Officer-in-charge of the Electron Microscope Unit, and Mr V. J. Bandu for their invaluable assistance in electron microscopy and the preparation of the photographic prints.

REFERENCES

- BRIQUET, J., 1897. Verbenaceae. In: A. Engler und K. Prantl: *Die natürlichen Pflanzenfamilien*. Band IV. 3a: 132–182.
- FAHN, A. and SHIMONY, C., 1977. Development of the glandular and non-glandular leaf hairs of *Avicennia marina* (Forsskål) Vierh. *J. Linn. Soc., Bot* **74**: 37–46.
- INAMDAR, J. A., 1969. Epidermal structure and ontogeny of stomata in some Verbenaceae. *Ann. Bot.* **33**: 55–66.
- METCALFE, C. R. and CHALK, L., 1950. *Anatomy of the Dicotyledons*. Vol. 2. Oxford: Clarendon Press.
- MOLDENKE, H. N., 1938. A monograph of the genus *Petrea*. *Feddes Rep.* **43**: 1–48, 161–221.
- NAPP-ZINN, K., 1973. *Anatomie des Blattes*. II. Blattanatomie der Angiospermen. Berlin und Stuttgart: Borntraeger.
- SOLEREDER, H., 1899. *Systematische Anatomie der Dicotyledonen*. Stuttgart: Enke.
- VESQUE, J., 1885. Caractères des principales familles gamopétales. tires de l'anatomie de la feuille. *Ann. Sci. nat. 7e Sér., Bot.* **1**: 183–360.

LEAF ANATOMY OF *JUBAEOPSIS CAFFRA* BECC.

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ABSTRACT

The anatomy of the lamina and leaf sheath of *Jubaeopsis caffra*, an endemic palm from the east coast of South Africa, was studied. Observations were recorded and comparisons were made with other cocosoid species. Generally the leaf anatomy of *J. caffra* was found to be similar to that of most other cocosoid genera, but a few distinguishing differences were noted. The most significant of these is in respect of the anticlinal walls of the adaxial epidermis cells. These cell walls are sinuous and distinguish *Jubaeopsis* from all cocosoid genera except *Orbignya*. Further, the margins of the leaflets are slightly ribbed. This is in contrast to the other cocosoid species where no marginal rib is present.

UITTREKSEL

BLAARANATOMIE VAN *JUBAEOPSIS CAFFRA* BECC.

Die anatomie van die lamina en blaarskede van *Jubaeopsis caffra*, 'n endemiese palm vanaf die Suid-Afrikaanse ooskus, is ondersoek. Waarnemings word beskryf en 'n vergelyking met ander cocosoid spesies word gemaak. Oor die algemeen stem die blaaranatomie van *J. caffra* ooreen met die meeste ander cocosoid genera, maar 'n paar uitstaande kenmerke is waargeneem. Die belangrikste hiervan is ten opsigte van die antiklinale wande van die adaksiale epidermisselle. Hierdie selwande is gekartel en onderskei *Jubaeopsis* van alle ander cocosoid genera behalwe *Orbignya*. Verder, is die rande van die blare effens gerib. Dié is in teenstelling met die ander cocosoid spesies waar geen marginale rib aanwesig is nie.

INTRODUCTION

Tomlinson's (1961) classic work on the anatomy of the palms deals so completely with the literature on this subject that it would be superfluous to give a complete review thereof here. Although Tomlinson does describe the anatomy of the cocosoid palms in general and that of a number of genera in particular, no information concerning the anatomy of *Jubaeopsis caffra* is available. In view of this it was felt that a study of the anatomy of this species would be justified.

Although the leaf, stem and root were examined, it is the anatomy of the leaf, and in particular that of the lamina, which exhibits by far the most diagnostic features (Tomlinson, 1961). Consequently only data relating to the anatomy of the lamina and leaf sheath are presented in this paper.

MATERIAL AND METHODS

All the plant material used in this study was collected from trees in the *Jubaeopsis* groves on the estuary of the Mntentu river in Pondoland on the east coast of South

Accepted for publication 5th October, 1977.

Africa. Fixation of the material was in formaldehyde/ethyl alcohol/acetic acid (Sass, 1958).

Dehydration was accomplished with a graded tertiary butyl alcohol (TBA)-ethyl alcohol series while infiltration with wax was achieved by using a graded TBA-paraffin wax series. The material was embedded in paraffin wax (Carowax; melting point 54-58 °C).

Sections were cut on a rotary microtome at a thickness of 10 μ m. These were stained with safranin and counterstained with fast green (Brooks, Bradley & Anderson, 1950; Holtzhausen, 1972).

Material used in the SEM study was air-dried and coated with palladium-gold (Robbertse, 1974) prior to viewing in a Jeol JSM-U3 microscope.

Although some sections of *Jubaea* material were made, the comparisons of *Jubaeopsis* with *Jubaea* and other species are discussed mainly on the basis of Tomlinson's (1961) descriptions of these species.

RESULTS

Lamina

The mesophyll is clearly demarcated into adaxial palisade tissue and abaxial spongy parenchyma and consequently the leaf of *J. caffra* is dorsiventral (Fig. 1).

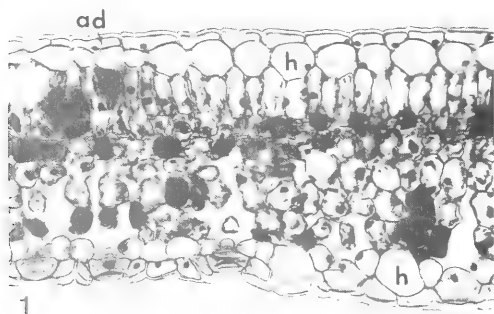


FIG. 1.
Longitudinal section of the leaflet lamina of *J. caffra*. $\times 150$.
(Ad—adaxial epidermis; h—hypodermis).

Thin flakes or layers of wax occur on the surface of the leaflets (Fig. 2) but only a small amount of wax is present.

Epidermal hairs also occur on both surfaces. These hairs consist of a larger, thin-walled sunken basal cell and four or five thin-walled distal cells arranged radially around the distal tip of the basal cell (Figs 3 & 4). These hairs are restricted to the intercostal regions. A second type of epidermal appendage occurs in the form of scale-like outgrowths along the midrib.

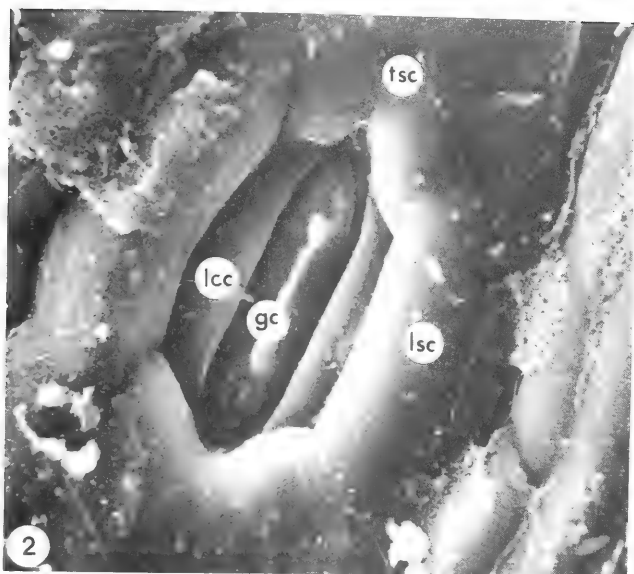


FIG. 2.

Stereoscan micrograph of stoma. $\times 1000$.

(gc—guard cell; lcc—lateral contact subsidiary cell; lsc—lateral subsidiary cell; tsc—terminal subsidiary cell).

The adaxial surface is covered by a thick cuticle while that on the abaxial epidermis is slightly thinner (Fig. 1). The cuticle is smooth and has no characteristic features or patterns, except on the guard cells. (These cells are discussed later).

Along the leaflet margins and on the adaxial side of the midrib the cuticle is particularly thick (Figs 6, 7 & 10).

In *J. caffra* the outer tangential walls of the epidermis cells are largely cutinised and are thick (Figs 1, 3, 6–8, 10, 11) especially in the case of the adaxial epidermis and in the vicinity of the midrib and margin. The cell walls are however not lignified. While the tangential or anti-clinal cell walls of the adaxial epidermis appear somewhat sinuous in a surface view (Fig. 5) those of the abaxial epidermis are only slightly sinuous to non-sinuous (Figs 12 & 13).

Adaxially no costal and intercostal bands are distinguishable, but abaxially the epidermis cells of these two regions differ mainly in respect of size with the costal cells slightly larger and broader than the intercostal epidermis cells (Fig. 12). The costal bands are narrower than the intercostal ones (Fig. 12).

The cells of the epidermis are longitudinally extended but are rather shallow (Figs 1, 3, 11 & 12). Around the leaf margin and the midrib however, the

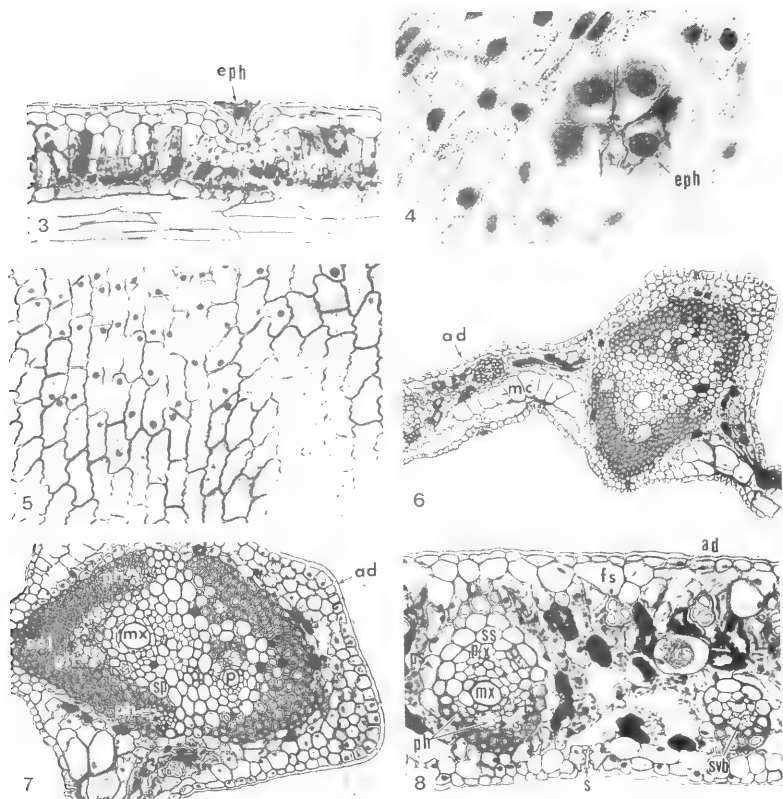


FIG. 3.

Longitudinal section through a portion of the lamina showing an adaxial epidermal hair (eph). $\times 150$.

FIG. 4.

Surface view of the epidermal hair (eph). $\times 400$.

FIG. 5.

Surface view of the adaxial epidermis of the leaf. $\times 180$.

FIGS 6 & 7.

Transverse section through leaflet midrib. $\times 60$; $\times 150$ resp. (ad—adaxial surface; mc—motor or expansion cells; mx—metaxylem; p—peripheral bundle; ph—phloem, sch—sclerenchyma; sp—sclerotic parenchyma).

FIG. 8.

Transverse section through lamina. $\times 150$. (ad—adaxial surface; fs—fibrous strands; mx—metaxylem; ph—phloem; ps—parenchymatous sheath; px—protoxylem; rs—raphide sac; s—stoma; ss—sclerenchymatous sheath; svb—small vascular bundle).

epidermis cells are uniformly isodiametric (Figs 7 & 10). The abaxial epidermal cells over the hypodermal expansion or motor cells on either side of the midrib are distinctly papillose (Fig. 6).

The stomata are restricted to the abaxial surface and specifically to the intercostal bands where they are very numerous (Fig. 12). The stomatal complex found in this species appears to be similar to that described by Tomlinson (1974) for *Cocos* and other Palmae, viz. a complex which originates from non-intersecting oblique divisions in the neighbouring cells. Each stoma is surrounded by six subsidiary cells (Figs 2 & 13). Two of these are terminal subsidiary cells and are short, thin-walled kidney-shaped cells (Figs 2 & 13) which are not sunken (Fig. 2). The two lateral contact cells are very narrow cells with the non-contact walls, i.e. walls not in contact with the guard cells being thickened (Fig. 13). These cells are distinctly sunken and envelope the guard cells (Figs 2, 8 & 14). The remaining two large lateral subsidiary cells are not sunken (Figs 2 & 14). The guard cells, which are sunken (Figs 2, 8 & 14) are small and thin-walled and are provided with a prominent outer and slightly less prominent cutinised ledge (Fig. 14).

A hypodermis of large cells occurs beneath both the adaxial and abaxial surfaces. In each case only a single layer of hypodermal cells occurs (Fig. 1 & 8) except in the vicinity of the margin and the midrib (Figs 6, 7, 10 & 11). Cells of the hypodermal layers are thin walled. The shape and size of the adaxial and the abaxial hypodermal cells tend to be irregular (Figs 8 & 12). In the abaxial hypodermis the intercostal hypodermis cells are somewhat larger than the costal hypodermis cells (Figs 8 & 12).

Each substomatal chamber is surrounded by four L-shaped abaxial hypodermis cells (Fig. 9).

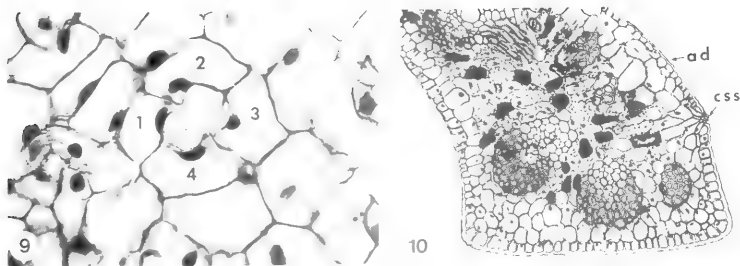


FIG. 9.

Paradermal section through abaxial hypodermis of the leaf showing four L-shaped cells (1-4) around the sub-stomatal chamber. $\times 360$.

FIG. 10.

Transverse section through the leaf margin. $\times 90$. (ad—adaxial surface; css—connecting strip scar.)

The chlorenchymatous mesophyll is clearly demarcated into an adaxial palisade tissue and abaxial spongy parenchyma (Fig. 1).

Generally only one or two layers of palisade cells are present. In a surface view the palisade cells which appear more or less circular, are densely packed into neat longitudinal files between the strands of fibres which run parallel to the long axis of the leaflet (Fig. 15), while the cells of the spongy parenchyma are extended transversely (Fig. 16) at right angles to the axis of the leaflet.

Three types of idioblasts occur in the mesophyll, viz. (i) a large number of tanniferous cells, (ii) raphide-sacs and (iii) silica cells or stegmata. The tanniferous cells occur throughout the parenchymatous tissues of the lamina and leaf

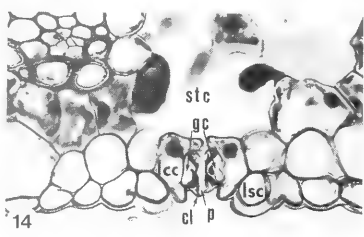
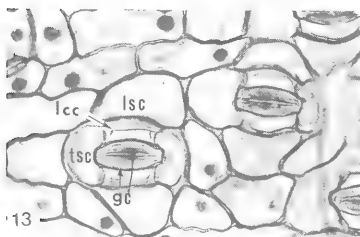
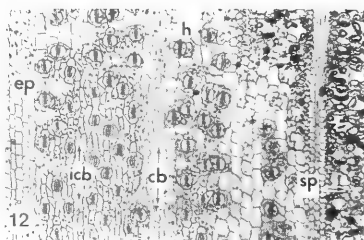
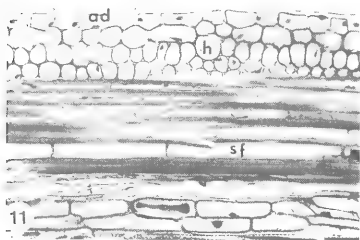


FIG. 11.

Longitudinal section through leaflet midrib. $\times 150$. (ad—adaxial surface; h—hypodermis; sf—septate fibres).

FIG. 12.

Oblique surface section through the abaxial epidermis of the lamina. $\times 60$. (cb—costal band; ep—abaxial epidermis; h—hypodermis; icb—intercostal band; sp—spongy parenchyma).

FIG. 13.

Surface view of the abaxial surface of the lamina showing the organisation of the stomatal components. $\times 360$. (gc—guard cells; lcc—lateral contact cell; lsc—later subsidiary cell; tsc—terminal subsidiary cell).

FIG. 14.

Transverse section through a stoma. $\times 360$. (cl—cuticular ledge; lcc—lateral contact cell; gc—guard cells; lsc—lateral subsidiary cell; p—pore; stc—substomatal chamber).

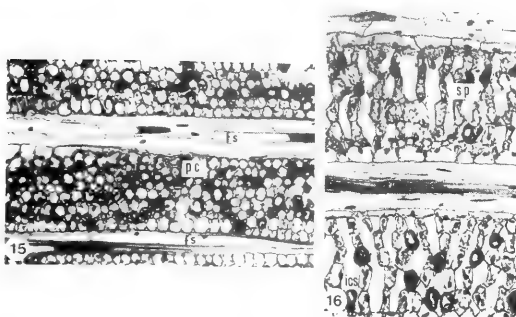


FIG. 15.

Paradermal section through the lamina of a leaflet, showing the closely packed chlorenchyma and fibrous strands. $\times 160$. (fs—fibrous strands; pc—palisade chlorenchyma).

FIG. 16.

Paradermal section through the abaxial portion of the lamina, showing the transversally extended spongy parenchyma cells. $\times 160$. (ics—intercellular spaces; sp—spongy parenchyma).

sheath. Sacs containing raphide clusters occur as large cells elongated parallel to the long axis of the leaflets (Figs 8 & 17). Each cell contains a bundle or sheaf of needle-like crystals which are embedded in densely staining mucilage. With regard to the stegmata, the silica bodies in cells are spherical. Although these cells are numerous, they are found only in association with vascular bundles and fibrous bundles. The stegmata occur in single longitudinal files around these bundles (Fig. 18). The walls of the stegmata are slightly lignified and very often these cells occur in depressions in the walls of the fibres.

Numerous non-vascular fibres are present in the lamina. These occur singly and in groups or strands and are situated mainly beneath the adaxial hypodermis (Fig. 8). Only a small number of fibrous strands occur abaxially. In a transverse section these fibrous strands are small and consist mainly of between one and six fibres. At the margin however, the fibrous bundles are much thicker (Fig. 10). These fibres are thick-walled, septate (Fig. 15) and often unlignified.

The venation of the lamina is parallel and includes longitudinal veins of various sizes connected by transverse commissures (Fig. 19). Basically two sizes of veins occur (excluding the midrib). The largest of these, which often contains a single large metaxylem vessel, is more or less centrally situated in the mesophyll and is connected to the epidermis by a fibrous sheath. The small vascular bundles on the other hand are restricted to the abaxial mesophyll and connected to the abaxial surface only (Fig. 8).

The large vascular bundles are sheathed by an outer parenchymatous layer and an inner sclerotic layer. The outer sheath is uniseriate and consists of large,

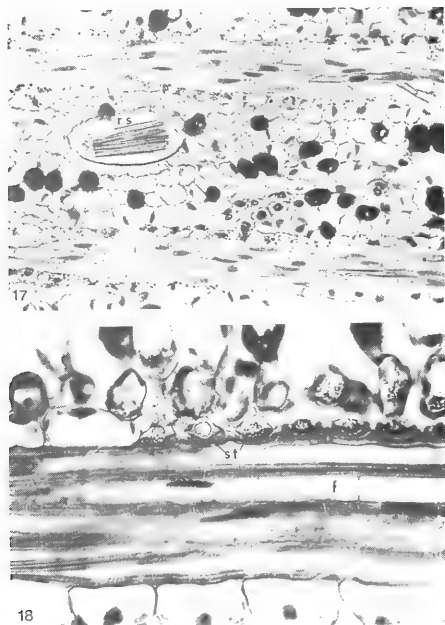


FIG. 17.

Paradermal section through the lamina showing a raphide sac (rs) in the mesophyll. $\times 230$.

FIG. 18.

Longitudinal section through lamina showing stegmata and silica bodies associated with fibres. $\times 570$. (f—fibres; st—stegmata with spherical silica bodies).

vertically extended (in a transverse section) parenchyma cells containing only a small number of chloroplasts. This sheath usually occurs only laterally to the vein and is often absent from the adaxial and abaxial regions (Fig. 8). The inner sheath is multiseriate and is comprised of fibres and sclerotic parenchyma, the fibres being limited mainly to the adaxial zone (Fig. 8). These fibres are lignified and are easily distinguishable from the adaxial fibre buttresses which connect the veins with the adaxial hypodermis. The outer sheath of the small veins is not well differentiated. The inner sheath is also somewhat reduced and consists adaxially of a single layer of sclerotic parenchyma and abaxially of two or three layers of fibres.

The xylem consists mainly of protoxylem vessels and xylem parenchyma. It is normally very difficult to distinguish between these tissues and the sclerenchymatous sheath, especially in the small veins, when viewed in transverse section. The

larger veins however normally contain a single large metaxylem vessel which is easily distinguishable (Fig. 8).

The phloem occurs abaxially in the vascular bundles. It is separated from the xylem by at least one cell layer of sclerenchyma (Fig. 8). Normally the phloem, which includes sieve tubes, companion cells and phloem parenchyma is divided into more than one group in the midrib only, but not in the other veins (Figs 6-8 & 10).

The midrib is adaxially very prominent (Fig. 6). As mentioned earlier, the epidermis cells are fairly uniform, but the abaxial ones are somewhat smaller than the adaxial epidermis cells, and the adaxial cuticle is thicker than that of the abaxial surface (Fig. 7).

Adaxially the hypodermis of the midrib is multiseriate and comprises three layers of large parenchyma cells (Figs 6, 7 & 11). Abaxially, the hypodermis cells are small in the centre of the rib, but are laterally confluent with the expansion cells and thus increase in size on either side of the midrib (Figs 6 & 7).

In the midrib there is a thick multiseriate fibrous cylinder surrounding the central ground tissue. This cylinder is composed of two crescent-shaped sections, one adaxially and the other abaxially orientated. Where these two sections join, i.e. more or less across the middle of the midrib (in transverse section) the cell walls are somewhat thinner (Figs 6 & 7).

The central ground tissue, which consists mainly of sclerenchymatous tissue or sclerotic parenchyma, envelops the vascular bundles. A large vascular bundle is situated abaxially and consists of xylem (with a single large metaxylem vessel)

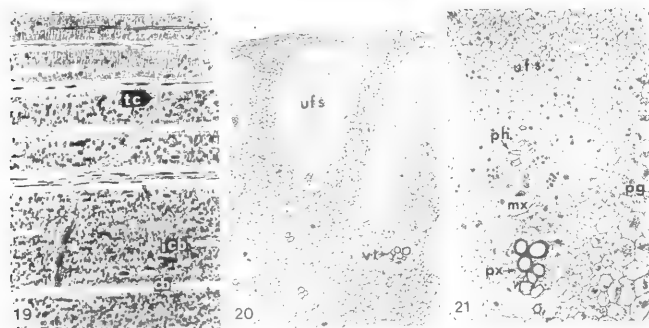


FIG. 19.

Paradermal section of leaflet in which transverse commissures are evident. $\times 25$. (cb—costal bands; icb—intercostal bands; tc—transverse commissures).

FIGS 20 & 21.

Transverse section through the dorsal portion of the spear-leaf sheath. $\times 25$; $\times 160$ resp. (mx—metaxylem; pg—starch-rich parenchymatous ground tissue; ph—phloem; px—protoxylem; ufs—undifferentiated fibrous sheath or cap; vt—vascular tissue).

and three or four small groups of phloem separated from each other and from the xylem by partitions of sclerenchyma. A second, smaller vascular bundle is adaxially situated, but is of a more compact nature (Figs 6 & 7). Peripheral vascular bundles do occur in the midrib (Fig. 7) but are rare.

Two abaxial bands of expansion cells occur in the leaflet. These are present as bands on either side of the midrib and run parallel to the midrib (Fig. 6). They consist of one or two hypodermal layers of very large, colourless parenchyma cells which occupy more than half the depth of the lamina. Although the two bands are confluent with the hypodermis of the midrib the cells of the midrib hypodermis are not differentiated into expansion cells. No fibrous strands occur within these bands.

Although the lamina of cocosoid palms does not normally have a well-differentiated margin, that of *J. caffra* is rather prominent (Fig. 10). The cuticle, epidermis and hypodermis in this region are very similar to those of the midrib. Further, the veins in the margin possess very thick abaxial fibrous caps. The epidermis of the lamina is interrupted at a point near the margin by the "scar" left by the connective strip which connects the leaflets of the lamina with each other in the developing leaf (Fig. 10).

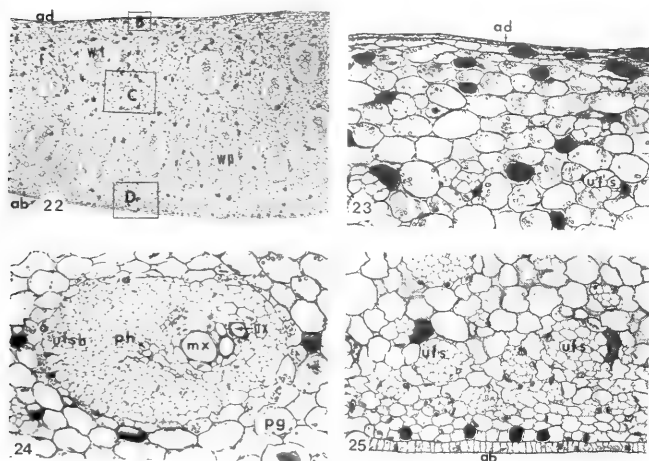
Leaf sheath

The sheath of the spear leaf, i.e. the oldest, unopened leaf, is still meristematic and consequently it is largely parenchymatous and no sclerotic tissue has differentiated at this stage (Fig. 20). However, associated with each vascular bundle is a group of cells which are much smaller in diameter than the cells of the surrounding parenchymatous ground tissue (Figs 20 & 21).

These cells constitute undifferentiated fibres which, after differentiation, give the sheath its tremendous strength and durability. The peripheral bundles in the dorsal section of the sheath are associated with exceptionally large, fibrous caps (Fig. 20). In the spear leaf the vascular tissue in the leaf sheath consists of protoxylem, one group of phloem per bundle and vascular parenchyma. Differentiation of metaxylem is initiated at about this time (Fig. 21).

The cells of the ground tissue are very rich in starch (Figs 21 & 23).

In the sheath of the youngest expanded leaf, the cells are also still mainly un lignified and no sclerenchyma is evident (Figs 22–25). The adaxial cells of the ventral section however, become tangentially elongated, probably as the result of the expansion in diameter of the stem (Fig. 23). Apart from the group of undifferentiated fibres associated with the vascular bundles, numerous strands of undifferentiated non-vascular fibres become evident. Although these are scattered throughout the ground tissue (Figs 22 & 25) they are concentrated in the abaxial peripheral region (Fig. 25). At this stage each vascular bundle consists of a large undifferentiated fibrous sheath, a number of protoxylem vessels, a single large metaxylem vessel, two groups of phloem and vascular parenchyma (Fig. 24).



FIGS 22-25.

Transverse section through the ventral portions of the sheath of the youngest expanded leaf.

FIG. 22.
×25.

FIG. 23.
Portion B of Fig. 22. ×160.

FIG. 24.
Portion C of Fig. 22. ×160.

FIG. 25.
Portion D of Fig. 22, showing the peripheral fibrous bundles (still unsclerified) in the abaxial portion of the leaf sheath. ×160.

(ab—abaxial surface; ad—adaxial surface; f—"filling" fibrous strands; mx—metaxylem; pg—parenchymatous ground tissue; ph—phloem; px—protoxylem; ufs—unsclerified fibrous strand; ufsh—unsclerified fibrous sheath; wp—"warp" vascular bundles; wt—"weft" vascular bundles).

As the leaf matures, sclerification of the fibres takes place and each vascular bundle is associated with a large sclerotic cap (Fig. 26). The number of metaxylem elements increases, but still only two groups of phloem are present. Further, a large amount of sclerotic parenchyma occurs in the vascular bundles (Fig. 27). In a longitudinal section through the ventral tissues of the sheath, the vascular bundles are not perfectly vertical but are arranged at a slight angle to the left and right. The adaxial bundles which constitute the "weft", are angled upwards from right to left on the one side of the ventral line and from left to right on the opposite side of this line. The abaxial bundles, i.e. the "warp" on the other hand, are orientated in precisely the opposite manner. The type of leaf sheath found in

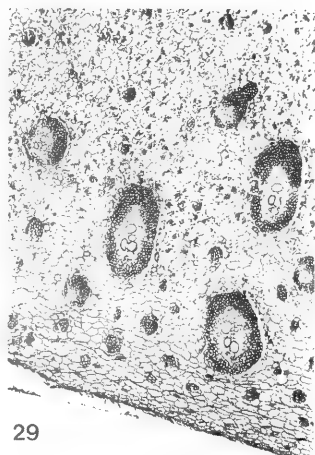
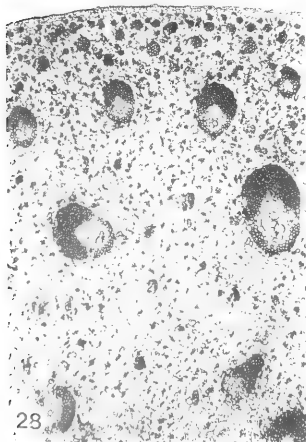
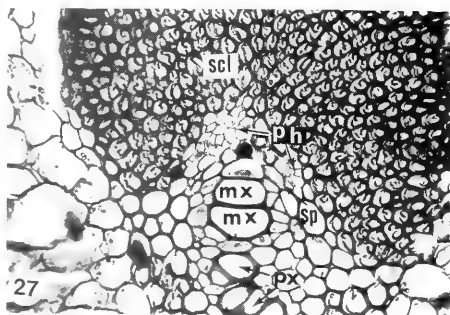
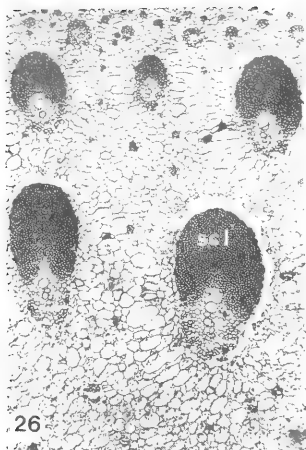


FIG. 26.

Transverse section through the ventral tissues of the sheath of a mature expanded leaf, showing the extent to which the fibrous sheath or phloem cap becomes sclerified. $\times 25$. (scl—sclerenchyma).

FIG. 27.

Enlargement of one of the vascular bundles in Fig. 26. $\times 160$. (mx—metaxylem; ph—phloem; px—protoxylem; scl—sclerenchyma; sp—sclerotic parenchyma).

FIG. 28.

Transverse section through the abaxial ventral tissues of a mature leaf sheath showing the "warp" vascular bundles. $\times 25$.

FIG. 29.

Transverse section through the adaxial vascular bundles of the same leaf as in Fig. 28. These bundles constitute the "weft". $\times 25$.

Jubaeopsis caffra is intermediate between the *Phoenix* and *Cocos* types (Robertson, 1977). As can be seen from Figs 28 and 29, there is very little difference in thickness and the extent of sclerification between the warp and weft bundles. The numerous, non-vascular fibrous bundles constitute the "filling". (The terminology used here is that proposed by Tomlinson, 1964).

DISCUSSION AND CONCLUSIONS

The dorsiventrality of the leaf of *J. caffra* is in accordance with the majority of other cocosoid genera.

The epidermal hairs which occur on the leaf of *J. caffra* are similar to those of *Orbignya*, *Elaeis* and *Syagrus* in that they consist of a single inflated, distinctly sunken basal cell and a number of thin-walled distal cells, but differ from those of *Jubaea* in which the basal cell is not sunken and from those in *Cocos* where three or four basal cells occur.

As far as the adaxial epidermis of the leaf is concerned, *J. caffra* differs from all the cocosoid palms except *Orbignya*, in that the anticlinal cell walls are sinuous. Further, *J. caffra* differs markedly from *Jubaea* in that the adaxial epidermis cells of the former species are longitudinally elongated, while in the latter case, the cells are transversely elongated (Tomlinson, 1961).

As in other cocosoid genera, the stomata of *J. caffra* are restricted to the intercostal bands of the abaxial surface. The stomatal complex of *J. caffra* is similar to that described by Tomlinson (1974) for *Cocos nucifera*. According to Tomlinson (1961) the guard cells are not sunken, except in *Scheelea* and *Syagrus yatai*. In this respect *J. caffra* is similar to the latter two cases in that the guard cells are distinctly sunken (Figs 2 & 13).

Both the adaxial and abaxial hypodermis layers of *J. caffra* are only one cell layer thick (Fig. 1). In this respect it is similar to *Elaeis* and *Orbignya*, but dissimilar to *Cocos* which has an adaxial hypodermis of one or two cell layers. *Jubaea* on the other hand has a well-developed adaxial hypodermis, consisting of three cell layers while a single cell layer occurs beneath the abaxial epidermis.

The chlorenchyma of most cocosoid palms is usually demarcated into distinct adaxial palisade layers and abaxial spongy parenchyma. *J. caffra* leaves exhibit the same structure and differ thus from *Jubaea* in which no spongy parenchyma occurs. The entire mass of chlorenchyma in the leaf of this latter genus consists of palisade tissue (Tomlinson, 1961).

Orientation of the fibrous strands in the leaf of *J. caffra* is similar to the majority of genera in this sub-family in that they occur mostly as adaxial, sub-hypodermal strands with only a few abaxial strands. Again, *J. caffra* differs quite markedly from *Jubaea* which has very few non-vascular fibrous strands.

Similarly, *J. caffra* differs from *Jubaea* but is basically similar to the majority of cocosoid genera in respect of the orientation of the veins in the lamina. Generally the large vascular bundles in most genera are centrally placed in the mesophyll

and have contact with both surfaces, while the smaller vascular bundles are abaxially situated and are connected to the abaxial surface only (Fig. 8). In *Jubaea* (Tomlinson, 1961) on the other hand, all the vascular bundles, irrespective of size, are in contact with both surfaces via fibrous buttresses.

In *J. caffra* three to four groups of phloem occur in the larger vascular bundles. These are separated from each other by strips of sclerotic parenchyma which radiate from the metaxylem vessel. In this respect it is similar to *Cocos*, *Coroza*, *Attalea*, *Elaeis* and *Maximiliana* (Tomlinson, 1961) but differs from *Jubaea* in which the number of phloem groups often exceeds four and which are separated by both vertical and horizontal sclerotic partitions.

The most significant difference between the midrib of *J. caffra* and that of *Jubaea* is to be found in the chlorenchyma. In *Jubaea* the central sclerotic cylinder of the midrib is surrounded by well-developed peripheral chlorenchyma which is continuous with that of the lamina. However, in *J. caffra* very little assimilatory tissue is present in this region (Fig. 7).

It appears that all cocosoid genera (except *Maximiliana*) have two abaxial bands of expansion cells—one on either side of the midrib of the leaflet. The composition of these bands though, is not the same in all genera. In *J. caffra*, for example, the bands consist of between one and two cell layers only (Fig. 7) while in *Jubaea* the equivalent cells are smaller, but between three and four cell layers are present.

Although Tomlinson (1961) states that the margins of the leaflets in cocosoid genera are not ribbed, *J. caffra* has a rather prominently developed margin, consisting of two to three hypodermal cell layers, two vascular bundles and a fibrous bundle. In this respect *J. caffra* is quite similar to the caryotoid palms which have distinct marginal ribs (Tomlinson, 1961).

The only detailed description of a cocosoid leaf sheath is of *Cocos nucifera* (Tomlinson, 1964). It would seem from the results of this study that the anatomy of *J. caffra*'s sheath is very similar to that of *C. nucifera*, except that there is little difference between the adaxial and abaxial bundles, i.e. weft and warp respectively, in *J. caffra*.

The general conclusions that can be drawn from this study are that although the anatomy of *J. caffra* is basically similar to the majority of other cocosoid palms, it does have certain distinguishing features. The most important of these being the sinuous anticlinal walls of the adaxial epidermis cells and the presence of a marginal rib.

Anatomically, the leaf of *Jubaeopsis* differs very markedly from that of *Jubaea* and the relationship between these two monotypic genera is perhaps not as close as suggested by Beccari (1913).

ACKNOWLEDGEMENTS

This study was supported by financial grants from the University of Port Elizabeth and the CSIR.

REFERENCES

- BECCARI, O., 1913. Una nuova "Cocoina" africana: *Jubaeopsis caffra*. *Webbia* **4**: 169-176.
- BROOKS, R. M., BRADLEY, Muriel V. and ANDERSON, Thelda I., 1950. *Plant microtechnique manual*. Davis: University of California.
- HOLTZHAUSEN, L. C., 1972. 'n Morfo-genetiese en fenologiese studie van die blom en vrug van *Citrus sinensis* (L.) Osbeck., cultivar *Valancia*. D.Sc. (Agric.) thesis. Pretoria: University of Pretoria.
- ROBBERTSE, P. J., 1974. A scanning electron microscopic investigation of the pollen of South African *Acacia* species. *Jl S. Afr. Bot.* **40**: 91-99.
- ROBERTSON, B. L., 1977. Aspects of the morphology of *Jubaeopsis caffra* Becc. Accepted for publication in October issue of *Principes*.
- SASS, J. E., 1958. *Botanical microtechnique*. Iowa: Iowa State University Press.
- TOMLINSON, P. B., 1961. *Anatomy of the monocotyledons*, II. *Palmae*. London: Oxford University Press.
- TOMLINSON, P. B. 1964. The vascular skeleton of the coconut leaf base. *Phytomorphology* **14**: 218-230.
- TOMLINSON, P. B., 1974. Development of the stomatal complex as a taxonomic character in the monocotyledons. *Taxon* **23**(1): 109-128.

A PRELIMINARY STUDY OF THE NITROGEN NUTRITIONAL STATUS OF MEMBERS OF THE SOUTH AFRICAN PROTEACEAE

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ABSTRACT

An investigation of the free amino compounds of *Leucadendron xanthoconus* and *Protea lepidocarpodendron* leaves indicate very low concentrations of these compounds present. An analysis of the xylem sap of *L. xanthoconus*, *P. lepidocarpodendron*, *P. laurifolia* and *Brabeium stellatifolium* also reveals very low levels of nitrogen transporting compounds present, the spectrum of these compounds being dominated by nitrate and ammonium ions, and glutamine. Feeding experiments with KNO_3 and NH_4Cl indicate poor utilisation of additional nitrogen supplies by *L. xanthoconus* shoots, particularly in the case of nitrate feeding. ^{15}N feeding experiments do, however, show limited nitrate reduction capability in the leaves of *L. xanthoconus*.

UITTREKSEL

'N VOORLOPIGE STUDIE VAN DIE STIKSTOF-VOEDINGSSTATUS VAN LEDE VAN DIE SUID-AFRIKAANSE PROTEACEAE

'n Ondersoek van die vrye aminoverbindings van *Leucadendron xanthoconus* en *Protea lepidocarpodendron* blare vertoon die aanwesigheid van baie lae konsentrasies van hierdie verbindings. Oplossings van die xileemsap van *L. xanthoconus*, *P. lepidocarpodendron*, *P. laurifolia* en *Brabeium stellatifolium* besit ook 'n baie lae konsentrasie van stikstofvervoerverbindings, met nitraat- en ammoniakione, en glutamien as die hoofkomponente. Voedings-eksperimente met KNO_3 en NH_4Cl vertoon swak benutting van sulke bykomende stikstofbronne deur uitspruitsels van *L. xanthoconus*, veral in die geval van nitraatvoeding. ^{15}N voedingseksperimente het egter bewys dat die blare van *L. xanthoconus* oor 'n beperkte vermoë beskik om nitraat te reduseer.

Although the fynbos of the South Western Cape has been known to civilised man longer than any other vegetation type in Southern Africa, it remains one of the most poorly studied of these types, especially in relation to its ecophysiological relationships. This apparent neglect of the country's most spectacular flora is probably occasioned by three main factors: the complexity of the flora itself; the fact that the topography and soils outside the regions exploited early in the country's history are not favourable for agronomy; and the physical and chemical characteristics of the natural vegetation which make it unsuitable for feeding livestock or for other forms of commercial usage other than cut flowers.

The investigation to be described is a preliminary study of one aspect of fynbos nutrition: the nitrogen status of the family Proteaceae and its comparison with that of non-fynbos families, in an attempt to understand this feature of the

Accepted for publication 31st October, 1977.

nutritional strategy of the fynbos employed in coping with the severe nutritional limitations of the soils of their vegetational area.

In this study the following four aspects of the nitrogen nutrition of representative species of Proteaceae have been investigated:—

1. The spectrum of free nitrogen compounds found in the leaves of the species, the quantities of these compounds present and a comparison of these data with that of non-fynbos plants.
2. The spectrum and relative quantities of the translocatory nitrogen compounds responsible for conveying nitrogen from soil to leaf via the xylem stream of the root and stem, and a comparison of these data with relative data obtained for non-fynbos representative species.
3. The effect of feeding additional supplies of nitrate or ammonium ions to the shoots of these plants to ascertain whether these supplies can be utilised and, if so, their influence on nitrogen metabolism in the leaf.
4. The nitrate reducing properties of the leaves of these plants and an assessment of the role of nitrate in leaf nitrogen nutrition.

PLANT MATERIAL and METHODS

Four species of Proteaceae, *Protea lepidocarpodendron* L., *Protea laurifolia* Thunb., *Leucadendron xanthoconus* O. Ktze. and *Brabeium stellatifolium* L. were investigated. *Protea lepidocarpodendron* and *Leucadendron xanthoconus* were growing at 300 m on the N.W.-facing slopes of Orange Kloof, Table Mountain, in soil derived from Table Mountain Sandstone. *Protea laurifolia* and *Brabeium stellatifolium* were growing respectively on the N.E.-facing slopes and the river valley floor of Happy Valley, Bains Kloof in Table Mountain Sandstone derived soil at an altitude of 630 m. Sampling was carried out during April and May 1976, i.e. in late autumn.

Leaf Sampling and Amino Compound Extraction. When leaf samples were removed from plants in the field, they were immediately killed and frozen by immersing them in liquid nitrogen. These frozen samples were returned to the laboratory where known weights of leaf material were homogenized in cold 80% ethanol (100 ml 80% ethanol for 5 g leaf material) using an Ultra Turrax homogenizer. The preparations were allowed to extract for 24 h at 0 ° in a sealed flask with occasional shaking, filtered and reduced in volume to 10 ml under an airstream.

Xylem Sap Extraction. Xylem sap was extracted from the plants by cutting off leafy twigs in the field and applying pressure to them inside a Scholander Bomb. The xylem sap extruded from the cut surface of the twig stem was collected and frozen immediately.

Soil Nitrate Analysis. Soil samples were collected in plastic bags from under the experimental plants and frozen immediately by immersing them in liquid nitrogen, thus killing the soil bacteria. These were transported to the laboratory,

dried at 30 °C and extracted by shaking in distilled water (1:1 weight/volume) for 30 min. Nitrate analysis was performed on soil extracts and xylem sap using an Orion Nitrate Probe coupled to an Orion Model 701 pH Meter.

Amino Compound Analysis. Amino acid and amide content estimates of leaf extracts and xylem sap were made on a Beckman 120C Amino Acid Analyser using the lithium buffer methodology described by Lewis (1975).

Nitrate and Ammonium Ion Feeding. Nitrate ion and ammonium ion solutions were fed to detached shoots of *Leucadendron xanthoconus* in the field as follows:

Shoots were detached from plants at 10h00, their severed ends recut under water to prevent xylem airblocks and placed into beakers containing either a 200 $\mu\text{g N ml}^{-1}$ KNO_3 solution or a 200 $\mu\text{g N ml}^{-1}$ NH_4Cl solution. These shoots were allowed to photosynthesize in sunlight alongside the plants from which they had been detached for 8 hours, when they were frozen and extracted as described above. Reference shoots were removed from the plants for analysis at the beginning of the experiment and at the end of the 8-hour period.

A further experiment in which nitrate was fed continuously to detached shoots of *L. xanthoconus* for 24 h was performed in a "Conviron" controlled environment cabinet under constant light (16 000 lux), a temperature of 16 °C and a relative humidity of 80 %.

The duplicated results of these feeding experiments are reported in Table 3.

^{15}N Isotope Studies on Nitrate Utilisation. In this experiment a leafy shoot of *L. xanthoconus* was fed a solution of 200 $\mu\text{g } ^{15}\text{N ml}^{-1}$ $\text{K } ^{15}\text{NO}_3$ for 24 h in a controlled environment cabinet under the conditions described above, to determine whether the shoots of this plant are able to reduce and utilise nitrate.

After extraction, the amino compounds of the extract were separated on a 150 \times 1.8 cm Beckman M-84 ion-exchange resin column and collected in a fraction collector. The amino compound samples were prepared for ^{15}N atomic emission analysis by Kjeldahl digestion and ammonia distillation. These analyses were performed on a Statron (Packard) atomic emission spectrophotometer following oxidation of the ammonia with sodium hypobromite by the method of Faust (1967).

RESULTS AND DISCUSSION

Free Amino Compounds in the leaves of *P. lepidocarpodendron* and *L. xanthoconus*

The levels of free amino compounds occurring in these leaves are indicated in Table 1. Also shown in this table are the relative figures for a non-fynbos plant typified by *Datura stramonium* L. growing in fertilised agricultural soil near Cape Town. The same amino-compound extraction procedure was used for *Datura* as for the fynbos plants.

From this table it can be observed that the free amino acid and amide levels in the leaves of *P. lepidocarpodendron* and *L. xanthoconus* are extremely low when

TABLE 1

The concentrations ($\mu\text{mol g fr. wt.}^{-1}$) of the free amino compounds of the leaves of two members of the Proteaceae compared with *Datura stramonium*.

Amino Acids	<i>Leucadendron xanthoconus</i>	<i>Protea lepidocarpodendron</i>	<i>Datura stramonium</i>
Aspartate	0,13	0,16	2,67
Threonine	0,10	0,07	1,16
Serine	0,30	0,26	0,94
Asparagine	0,04	0,07	0,69
Glutamate	0,30	0,36	3,68
Glutamine	0,03	0,09	1,45
Proline	—	—	—
Glycine	0,26	0,25	0,08
Alanine	0,10	0,13	0,48
Valine	0,01	0,02	0,01
Cystine	—	—	—
Methionine	—	—	—
Isoleucine	0,03	0,03	0,26
Leucine	0,03	0,03	0,07
Tyrosine	0,02	0,02	0,13
Phenylalanine	0,02	0,03	0,04
Lysine	0,25	0,15	0,13
Histidine	0,10	0,05	0,04
Arginine	0,01	0,01	1,00

compared with those of *D. stramonium*, with serine, glycine and glutamate dominating the amino acid spectrum.

This low free amino compound level is an indication that the level of N metabolism activity in these fynbos plants is low in comparison with that of plants adapted to living under more favourable soil N nutritional conditions.

Free Amino Compounds in the Xylem Sap of P. lepidocarpodendron, P. neriifolia, L. xanthoconus and B. stellatifolium

Table 2 shows a quantitative comparison of the amino compounds, nitrate and ammonium ions being transported from root to leaf via the xylem sap in the four Proteaceae species with those of *D. stramonium*. In the Proteaceae species the extremely low concentrations of nitrogen compounds found in the xylem sap are immediately obvious, indicating the very restricted supply of nitrogenous nutrients to the shoot in comparison with a plant adapted to a more favourable nutritional environment.

In all four fynbos plants, glutamine is the dominant amino compound present in the xylem sap, reflecting the importance of this amide as a translocator of reduced nitrogen from root to leaf in many plants. The major utilisable nitrogen carrier appears to be ammonium ions.

The unreduced nitrogen supply to the leaf in the form of nitrate present in the xylem sap, is greater than the total reduced nitrogen supply (amino compounds +

TABLE 2
The free amino compounds of the xylem sap of 4 species of Proteaceae compared with *Datura stramonium*.

Amino Compounds	<i>Leucadendron xanthoconus</i> $\mu\text{mol N ml}^{-1}$ xylem sap	<i>Protea lepidocarpidendron</i> $\mu\text{mol N ml}^{-1}$ xylem sap	<i>Brabeium stellatifolium</i> $\mu\text{mol N ml}^{-1}$ xylem sap	<i>Protea laurifolia</i> $\mu\text{mol N ml}^{-1}$ xylem sap	<i>Datura stramonium</i> $\mu\text{mol N ml}^{-1}$ xylem sap
Lysine	0.015	0.00	Trace	0.001	8.73
Histidine	Trace	0.001	Trace	0.002	6.42
Ammonia	0.198	0.174	0.030	0.054	23.91
Arginine	Trace	Trace	0.001	Trace	2.98
Aspartate	0.002	0.012	0.002	0.003	0.883
Threonine	Trace	0.004	0.001	Trace	1.310
Serine	0.003	0.010	0.002	0.001	0.180
Asparagine	Trace	0.003	0.002	Trace	3.297
Glutamate	0.002	0.008	0.002	0.002	2.063
Glutamine	0.012	0.040	0.030	0.014	25.31
Glycine	0.003	0.002	Trace	Trace	0.05
Alanine	0.001	0.005	Trace	0.001	0.190
Valine	—	—	—	—	4.80
Cystine	—	—	—	—	—
Methionine	—	—	—	—	—
Isoleucine	Trace	Trace	Trace	Trace	1.89
Leucine	Trace	0.001	Trace	—	2.47
Tyrosine	—	—	—	—	0.24
Phenylalanine	—	—	—	—	0.393
Nitrate N	0.800	1.200	0.300	0.400	173.0
Total N	1.036	1.463	0.370	0.478	258.12

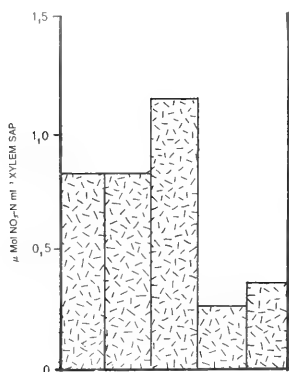


FIG. 1 (a)
Nitrate content of xylem sap of *Leucadendron xanthoconus* (LX) (two samples) *Protea lepidocarpodendron* (PL) *Brabeium stellatifolium* (BS) *Protea laurifolia* (PN)

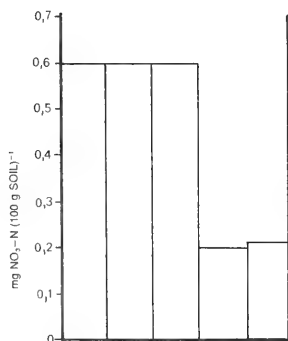


FIG. 1 (b)
Nitrate content of soils in which the plants were growing.

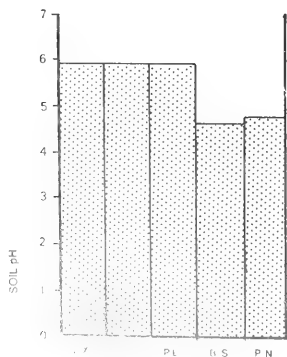


FIG. 1 (c)
pH of soils in which the plants were growing.

ammonium), but there is strong doubt as to whether this supply can be utilised by the leaf as the experiments to be described indicate.

The quantity of nitrate present in the xylem sap appears to be directly related to soil nitrate content and soil pH. Fig. 1 shows the correlation between xylem nitrate content, soil nitrate content and soil pH. The lower nitrate levels in the low pH Bains Kloof soils are probably a manifestation of the well known phenomenon of nitrifying bacteria inhibition in acidic soils.

The Effect of Nitrate and Ammonium Ion Feeding on Nitrogen Metabolism in Photosynthesizing shoots of L. xanthoconus

The results of the nitrate feeding experiments in which $200 \mu\text{g N ml}^{-1}$ was fed to photosynthesizing shoots via the xylem stream in the form of potassium nitrate are reported in Table 3. An inspection of this table shows no significant differences between the aminograms of experimental plants with their controls after a feeding period in the light of 8 h. After a 24 h feeding period there is a slight increase in the level of the N-incorporating amino acid, glutamic acid, indicating a small degree of nitrate ion utilisation by the shoots of *L. xanthoconus*.

The results of the ammonium feeding experiments in which $200 \mu\text{g N ml}^{-1}$ was fed to photosynthesizing shoots in the form of ammonium chloride are also shown in Table 3. An inspection of this table shows a considerable increase in the glutamine levels of the experimental plants compared with the control plants, indicating that the additional ammonium supply can to a large extent be incorporated into shoot metabolism. Glutamine has been shown to be an important contributor of reduced nitrogen to plant amino acid synthesis via the glutamate synthase pathway (Lee & Mifflin, 1974) and is known to accumulate in plants receiving high nitrogen nutrition (Lewis & Berry, 1975).

Nitrate Reduction by Shoots of L. xanthoconus

The ^{15}N enrichment of three important free amino acids of the leaf of *L. xanthoconus* after feeding K^{15}NO_3 (99 atom % excess) at the $200 \mu\text{g N ml}^{-1}$ level for 24 h is shown in Table 4. These enrichments are extremely low for a 24 h feeding period and confirm the poor nitrate processing properties of *L. xanthoconus* shoots. It nevertheless appears that the shoots do have limited nitrate

TABLE 4

^{15}N enrichment of glutamate, aspartate and threonine in leaves of *L. xanthoconus* fed K^{15}NO_3 ($200 \mu\text{g } ^{15}\text{N ml}^{-1}$) through the xylem stream for 24 h.

	^{15}N CONC. (ATOM % EXCESS)
GLUTAMATE	6,3
ASPARTATE	5,0
THREONINE	1,6

TABLE 3
Effect of feeding KNO_3 and NH_4Cl solutions at $200 \mu\text{g N m}^{-1}$ concentrations on free amino compound levels* ($\mu\text{mol g fr. wt.}^{-1}$) in leaves of *L. xanthoconus*.

	CONTROL (from shrub) (duplicate results)		KNO_3 -fed		(duplicate results)		NH_4Cl -fed (duplicate results)	
	8 h		8 h		24 h		8 h	
	8 h		8 h		24 h		8 h	
Aspartate	0.23	0.16	0.16	0.20	0.10	0.15	0.26	0.22
Threonine	0.04	0.05	0.06	0.07	0.05	0.04	0.07	0.12
Serine	0.15	0.07	0.19	0.25	0.04	0.12	0.40	0.30
Asparagine	0.02	0.02	Trace	Trace	Trace	Trace	0.03	0.15
Glutamate	0.27	0.19	0.17	0.20	0.36	0.51	0.47	0.64
Glutamine	0.03	0.02	Trace	Trace	0.05	0.10	1.99	1.33
Proline	—	—	—	—	—	—	—	—
Glycine	0.07	0.02	0.06	0.09	Trace	0.05	0.04	0.01
Alanine	0.05	0.01	0.06	0.08	0.20	0.20	0.19	0.04
Valine	—	—	—	—	—	—	—	—
Cystine	—	—	—	—	—	—	—	—
Methionine	—	—	—	—	—	—	—	—
Isoleucine	Trace	Trace	Trace	0.01	—	—	0.01	Trace
Leucine	—	—	—	0.01	—	—	0.01	Trace
Tyrosine	—	—	—	—	—	—	—	—
Phenylalanine	—	—	—	—	—	—	—	—

*Recognised reduced-N accepting compound in bold type.

reducing properties which may be further induced after prolonged exposure to high nitrate concentrations.

CONCLUSIONS

If the species investigated in this report can be considered representative of the Proteaceae, it would appear that this family has adapted to the poor nutrient status of the soils in which it grows by evolving a low intensity nitrogen metabolism to correspond with a slow growth habit. It would also appear that the shoots of *L. xanthoconus* are unable to utilise to any great degree high levels of nitrogen supplied to them, especially if the nitrogen is provided in the form of nitrate. Other workers (Groves & Keraitis, 1977) have shown, indeed, that high levels of nitrogen ($250 \mu\text{g N ml}^{-1}$) and phosphorus feeding can prove fatal to *Banksia serrata*, an Australian member of the Proteaceae, confirming the restricted nitrogen processing potential of the family.

REFERENCES

- FAUST, H., 1967. Probenchemie ^{15}N -markierter Stickstoffverbindungen im Mikro- bis Nanomolbereich für die emissionsspektrometrische Isotopenanalyse. *Isotopenpraxis* **3**: 100–103.
- GROVES, R. H. and KERAITIS, K., 1976. Survival and growth of seedlings of three sclerophyll species at high levels of phosphorus and nitrogen. *Aust. J. Bot.* **24**: 681–690.
- LEA, P. J. and MIFLIN, B. J., 1974. An alternative route for nitrogen assimilation in higher plants. *Nature, Lond.* **251**: 614–616.
- LEWIS, O. A. M., 1975. An ^{15}N – ^{14}C study of the role of the leaf in the nitrogen nutrition of the seed of *Datura stramonium* L. *J. exp. Bot.* **26**: 361–366.
- LEWIS, O. A. M. and BERRY, M. J., 1975. Glutamine as a major acceptor of reduced nitrogen in leaves. *Planta* **125**: 77–80.

A NEW SPECIES OF *PECTINARIA*

P. V. BRUYNS

ABSTRACT

A new species of *Pectinaria* Haworth is described from the Calvinia district.

UITTREKSEL

'N NUWE *PECTINARIA* SPESIES

'n Nuwe *Pectinaria* Haworth spesies vanaf Calvinia-distrik, word beskryf.

INTRODUCTION

Pectinaria, one of the smaller genera in the Stapelieae, is not known to occur outside the Cape Province. North of the Ceres-Karoo it is represented by *P. saxatilis* N.E.Br. around Vanrhynsdorp and by *P. articulata* Haw. var *namaquensis* N.E.Br. in the Springbok district. A few isolated records exist of *P. saxatilis* from the Calvinia-Loeriesfontein area.

Pectinaria exasperata Bruyns, sp.nov.

Caules aliquando conferti aggregati vel repentes sub terram, tum surgentes supra terram, partes sub terram albae, sine angulis manifestis, 5 ad 10 mm crassae, partes supra terram erectae, 10 ad 15 mm crassae apud planitiem terram, coartantes ad culminem rotundatum, armatae parvis dentibus, glabri; *flores* partim vel omnino subterranei; *pedicelli* glabri, 2 ad 5 mm longi cum floribus; *sepala* acuta, glabra; *corolla* 18 ad 20 mm longa; tubus ater purpureo-ruber basi, cetero pallidus puniceus, 10 ad 12 mm longus, coartans paululum prae initio lobis, papillatus intus cum prominentibus papillis; lobi aliquando conjuncti extremis, 7 ad 8 mm longi, 3 mm lati basi, papillati prope basim; *corona lobi exteriores* minutes, bidentates; *lobi interiores* 2 mm longi, atri purpureo-rubri.

Type material: CAPE—3119 (Calvinia): about 20 miles north of Calvinia (—BC), Bruyns 1345 (NBG, holo.).

Stems sometimes in a dense clump or else creeping underground from a central group of stems for about 40 mm or longer, then emerging above surface. Underground portion white, without obvious angles, 5–10 mm thick, above-ground portion erect, 10–40 mm long, dull grey-green, distinctly 4-angled, 10–15 mm thick at ground level, tapering (often abruptly) to a rounded top, armed with

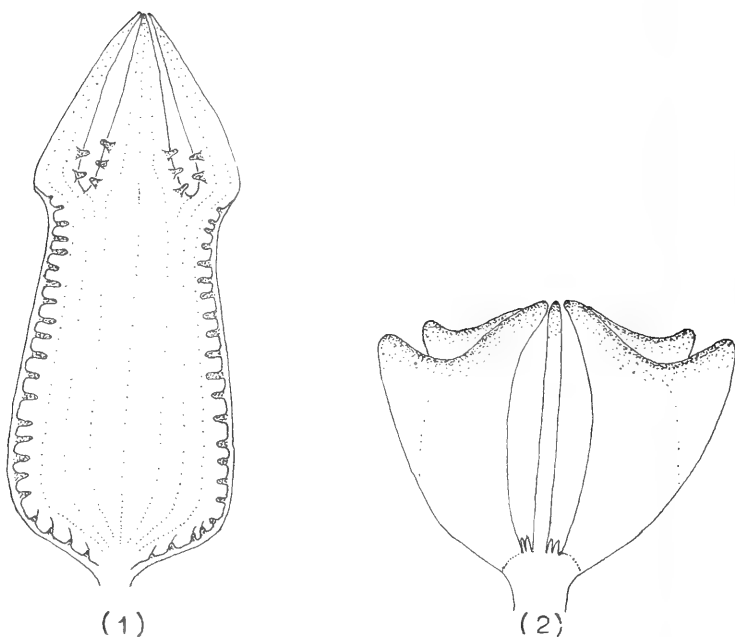


FIG. 1.
Pectinaria exasperata:

- (1) Corolla $\times 4.5$.
(2) Staminal column $\times 18$.

small sharp teeth on the angles, glabrous; *flowers* partially or entirely subterranean, arising in groups from a subterranean peduncle up to 10 mm long; *pedicels* glabrous, 2–5 mm long when with flowers, elongating to 10 mm after fertilisation. Before seed production elongate to 20–25 mm (coming just above soil surface) finally lengthening to 50 mm when follicles develop; *sepals* 3 mm long, 1 mm broad at base, acute, glabrous; *corolla* 18–20 mm long; tube cylindric-ovoid with deep purple-red base, the rest very light pink, 10–12 mm long, 4–7 mm broad at widest, narrowing slightly to 4–6 mm just below base of lobes, papillate within with prominent papillae covered with sub-globose, round-topped spicules, papillae becoming smaller towards base of tube, those in purple-red basal portion of tube each topped with a single hair up to 1 mm long; lobes 7–8 mm long, 3 mm wide at base, with a few papillae near base, very light pinkish-grey, with 5 intermediate decurved lobes up to 1 mm in length; *outer corona lobes* minute, bifid; *inner corona lobes* 2 mm long with a dorsal projection 1 mm in length, incumbent on anthers and meeting above stigmatic surface, dark



FIG. 2.
Pectinaria exasperata.

purple-red; *follicles* 100–120 mm long, with purple stripes on a light yellow background; *seeds* 4 mm long, 2 mm broad, with papillate margin, upper and lower surfaces rugose.

DISCUSSION

The structure of the inner corona lobes and the 4-angled stems place *P. exasperata* in the group within the genus *Pectinaria* consisting of *P. pillansii* N.E.Br., *P. saxatilis* N.E.Br., *P. stayneri* Bayer and *P. breviloba* R. A. Dyer. The partially to completely subterranean flowers are reminiscent of *P. pillansii*, a species further characterised by thick, decurved, intermediate corolla lobes. This latter feature is present to a much lesser degree in *P. exasperata*, but is not constant in that some flowers collected had very small and insignificant intermediate lobes. However, the erect, quadrangular above-ground portion of the stem and papillate corolla separate it from *P. pillansii* as well as from *P. saxatilis* and *P. stayneri*.

The growth habit of *P. exasperata* is very similar to that of *P. breviloba*. Both species creep underground with erect stem ends protruding at intervals. However, stems of *P. exasperata* are much thicker. As far as the flowers are concerned these two species differ in shape and size of the corolla and in colour. The inner corona lobes with considerable dorsal processes are similar to those of *P. saxatilis* as

recorded by Bayer and Plowes (1975) from Vanrhyn's Pass. In size they are similar to those of *P. saxatilis* from Vanrhyn's Pass as well as to those of *P. pillansii* and *P. breviloba*.

The name *P. exasperata* is adopted on account of the remarkably papillate inner surface of the corolla, visible even to the naked eye, a feature not found in any other member of the group to which it belongs.

ACKNOWLEDGEMENTS

Many thanks are due to Mr M. B. Bayer of the Karoo Garden, Worcester for generous help on numerous occasions. I wish also to thank Mr and Mrs P. Kotze of Jaagvlak, Calvinia for their kindness and hospitality.

REFERENCES

- WHITE, A. and SLOANE, B. L., 1937. *The Stapelieae*. 2. Pasadena, California: Abbey San Encino Press.
- BAYER, M. B. and PLOWES, D. C. H., 1975. Some Stapeliads of the Southern and South-Western Cape. *Excelsa* 5: 76-80.

SOME PROBLEMS OF SOUTH AFRICAN PTERIDOPHYTA

W. B. G. JACOBSEN

ABSTRACT

A number of South African Pteridophyta are discussed with the object to point out a few taxonomical, nomenclatural and distributional problems in the existing literature.

UITTREKSEL

SOMMIGE PROBLEME MET SUID-AFRIKAANSE PTERIDOPHYTA

'n Aantal Suid-Afrikaanse Pteridophyta word bespreek met die doel om 'n paar taksonomiese, nomenklatoriese en verspreidingsprobleme in bestaande literatuur aan te toon.

INTRODUCTION

The *Lycopodium gnidioides* complex is found to contain three different forms. A study of original description and type as well as experimental cultivation is called for to decide whether form 1 or form 3 have to be put on to subspecific or varietal level or are merely ecotypes. Form 2 appears to be identifiable with *L. gnidioides* L.f. var. *pinifolium* (Kaulf.) Pappe & Rawson.

Two separate forms of *Asplenium erectum* Bory ex Willd. are recognised and described and again it is suggested to embark on a study of types and experimental cultivation to solve the problem of eventual varietal status of one or the other.

An attempt is made to straighten out a certain amount of confusion with regard to the Southern African species of the genus *Polystichum*. Six species are discussed, of which one is described as a new species. A key to the six species is provided to facilitate identification in the field and in herbaria. The distribution of *P. setiferum* var. *fuscopaleaceum* sensu Schelpe is found to extend far into South Africa. Montane forms of this species and of *P. pungens* sensu Sim are described.

The *Dryopteris inaequalis* complex is found to contain two well distinguished forms, a large one with triangular fronds and distinct asymmetry of the basal pinnae (the common forest form) and a small fern with elliptical fronds and symmetrical basal pinnae. The forms have been kept separate under two specific epithets in the past, but were combined by Schelpe (1970) under the name *D. inaequalis* (Schlechtend.) Kuntze. It is suggested to separate the two forms again and to clarify their nomenclature and status.

A form of *Athyrium scandicinum* with a well developed caudex from the Eastern Transvaal is described. The unusual development of a caudex is ascribed to climatic conditions.

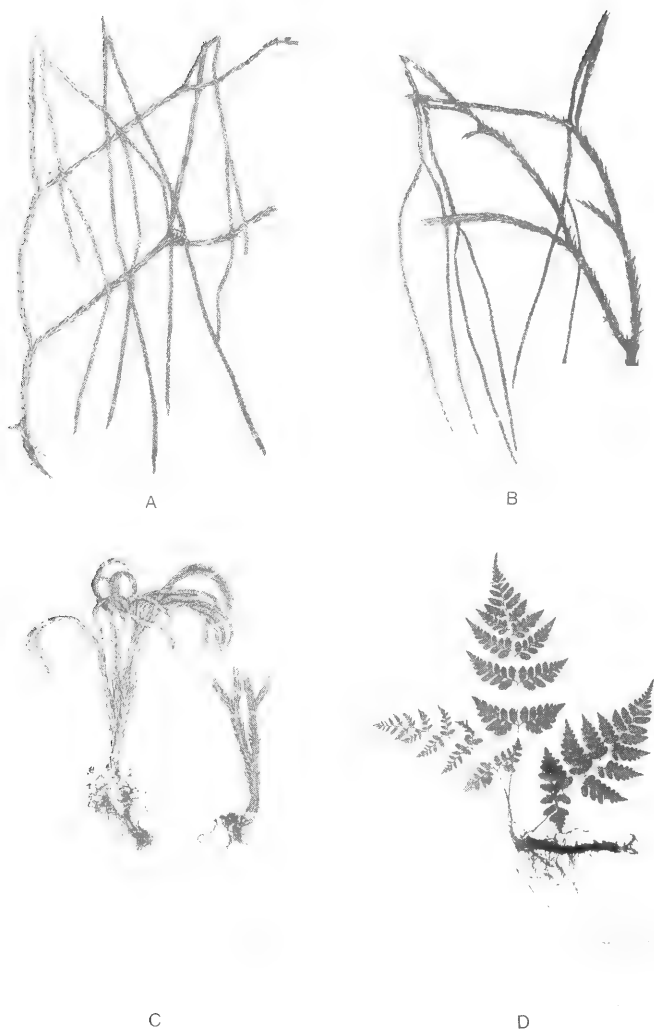


FIG. 1.

A, *Lycopodium gnidioides* L.f. Form 1 Note the closely addressed, rigid leaves and the long, fairly thick fertile spikes. Erasmus Kop, Eastern Transvaal, *Jacobsen 4391*; B, *Lycopodium gnidioides* L.f. Form 3 Note the slightly patent leaves and the long fertile spikes which are thinner than those of Figure A. Pirie Forest, Eastern Cape, *Jacobsen 4582*; C, *Lycopodium gnidioides* L.f. var. *pinifolium* (Kaulf.) Pappe & Rawson. Pilgrims Hill, Eastern Transvaal, *D. Mousse 52*; D, *Dryopteris inaequalis* (Schlechtend.) Kuntze? Note the thick, creeping rhizome, the elliptical-lanceolate shape of the frond and the slightly reduced, symmetrical basal pinnae. Hogsback Forest, Eastern Cape, *Jacobsen 4576*.

DISCUSSION

The Lycopodium gnidioides Complex

Lycopodium gnidioides is extremely variable in Southern Africa and attempts have been made at various times to subdivide it into several species or varieties. The author after studying his own material as well as that in the National Herbarium, Pretoria, found that there are three rather distinct forms which are illustrated on Fig. 1 A, B and C.

Form 1 coincides with Sim's (1915) plate 177 and is characterised by its pendant, rigid, yellow-green branches, which are often fertile to one half of their length of 300–800 mm. The leaves are tightly adpressed. The fertile spikes are 3–4 mm thick, the sporophylls are lanceolate, acute and keeled. A typical representative is shown on Fig. 1, A.

Form 2 compares in habitus with *Huperzia stricta* (Bak.) Tard. as illustrated in *Flore de Madagascar et des Comores*, 1971, Fig. IV, 5–8, and is characterised by its erect, rigid, yellow-green branches, with fertile spikes of only 50 mm length and 3–4 mm thickness. The maximum total height is 300 mm. The fertile spike is often pendulous. The leaves are closely adpressed, the sporophylls ovate, shortly acute and keeled. (See Fig. 1, C).

Form 3 has pendant, herbaceous, dark green branches, 400–800 mm long of which the fertile spike may take up one third at only 2–3 mm thickness. The leaves are loosely adpressed or somewhat patent, the sporophylls are lanceolate, acute, not keeled and slightly reflexed at the tips (Fig. 1, B).

In view of the rather confusing evidence in the pertaining literature a more detailed discussion of the species seems warranted. The species has been known for a long time and its first description originates from the younger Linnaeus in his *Supplementum*, p. 448 of 1781 on material collected by Sonnerat in Mauritius, with long branches, so that it would be representative of either form 1 or 3 above. From then on the species appears in the literature under a number of names. The first mention of the variable habitus of the species was made by Schlechtendal (1825–1832) writing that the plant may be either rigid and compressed or lax and diffuse and that the colour of the dried plants may be green or yellowish-green. His illustration (tab. 2) shows a pendant plant with fairly lax habitus and elongated, fertile spikes. Sim (1915) also depicts on Plate 177 a fairly lax plant with long fertile spikes and a similar illustration is brought by Tardieu-Blot (1971) for *L. gnidioides* on Fig. V, 12. It appears therefore fairly well established that the species in its original concept is generally accepted to be a fairly long, pendant plant, with elongated fertile spikes, growing as epiphyte or chasmophyte in shady forests.

Form 2

There is in South Africa and in the Malagassy Republic a stout, short, erect form, with short, pendulous, quadrangular fertile spikes, which grows in full sunlight on rocks on mountain tops or in streambeds, which although similar to *L. gnidioides* in its typical form is entirely different in habitus (Fig. 1, C). A plant of this type was described by Kaulfuss (*Enum.fil. Chamisso*, p. 7, 1824) as *Lycopodium pinifolium*, which had strobili of 1½–2 inches length. This species was reduced by Pappe & Rawson in 1858 to a variety of *L. gnidioides*, of which they give the following description:

“Leaves densely imbricate, coriaceous, decurrent, glossy, spikes two inches long, sessile, standing in pairs, branches dichotomous, fastigate, curved at the apex, bracts keeled. Stem erect, 10–12 inches high.”

This description corresponds in every detail with the mountain top form. In 1882 Baker described a similar plant from mountains in Madagascar as *Lycopodium strictum* and distinguishes this species from *L. gnidioides* as follows:

L. strictum: “Stems tufted, erect, poorly branched, 15–30 cm long, with the leaves 6–9 mm in diameter, leaves oblong or linear oblong, obtuse, ascending, imbricate and densely crowded, thick and rigid in texture, 6–9 mm long, midrib obscure. Spikes pendulous, single, 2½–4½ mm in diameter, bracts broadly ovate, very thick, closely imbricate, 1¾–2¼ mm long.”

L. gnidioides: “Stems pendulous, 30–60 cm or more long, several times dichotomously forked, with the leaves 12,5 mm in diameter. Leaves oblong-lanceolate, moderately dense, ascending, obtuse, thick in texture, glossy 9–12,5 mm long, midrib distinct. Sporangia in lax spikes, which are often 15 cm long, in the axils of thick ovate-oblong bracts, 3½–4½ mm long.”

Following the recent practice of splitting the family Lycopodiaceae into two subfamilies Lycopodiaceae s.s. and Huperziaceae (Rothm., *Repert. Sp. Nov.* 66: 236, 1962). Tardieu-Blot in *Adansonia* ser. 2, 10: 20 (1970) accepts Baker's *L. strictum* under the new combination *Huperzia stricta* (Bak.) Tard., but in 1971 (*Fl. de Madagascar et des Comores*, p. 30) considers *Lycopodium pinifolium* Klf. as synonymous with *Huperzia gnidioides* (L.f.) Trev. On Fig. IV, 5–8 (p. 31) she illustrates *Huperzia stricta*. The deviating habitus of the species agrees in the main with a number of the author's own specimens as well as with many sheets at PRE (Fig. 1, C). There is, however, some disagreement between recorded measurements of leaves and sporophylls between Tardieu-Blot, Schelpe (in a personal communication to Mr P. Vorster of the Botanical Research Institute, Pretoria) and the author as the following tabulation shows:

	Tardieu-Blot	Schelpé	Author
Leaves:			
Length mm	6-8	8-10	12-13
Width mm	1,5	2,5-3	1,75-2
Sporophylls:			
Length mm	2	2,5	4
Width mm	2	2	2,75

Schelpé found slightly smaller dimensions in the Malagassy material than in the South African forms, but there is a rather formidable difference between his figures and the author's, whose specimens originate mainly from the Eastern Transvaal.

Leaving the general acceptance of the subdivision of the Lycopodiaceae and of the genus *Lycopodium* to be settled by taxonomists and adhering for the time being to the concept of the genus *Lycopodium* sensu lato the question arises whether the form 2 should be maintained as a separate species, should be put on to subspecific or varietal level or as Schelpé (1970) has done, should be combined with *L. gnidioides*. Morphological differences between it and what is generally considered to be *L. gnidioides* are slight, the forest plant usually having slightly larger leaf dimensions. But the decisive factor appears to be the totally different habitus, which may, of course, be due merely to an adaptation to different ecological conditions, in which instance the plant would have to be classed as an ecotype of *L. gnidioides*. Transitions to the forest forms, however, seem to be lacking, so that the author is inclined to propose acceptance as a variety of *L. gnidioides*, a view, which Schelpé seems to support—at least for the Malagassy plant. Kaulfuss' *L. pinifolium*, which was reduced by Pappe & Rawson to *L. gnidioides* var. *pinifolia* was based on a type from South Africa. This varietal epithet has preference before Baker's epithet "*strictum*". The author proposes, therefore, to reinstitute the name *Lycopodium gnidioides* L.f. var. *pinifolium* (Kaulf.) Pappe & Rawson for this plant.

Further specimens of this variety in the examined herbaria are:

Author: Mount Sheba Nature Reserve, *Jacobsen 4449*; Ohrigstad Nature Reserve, *N. Jacobsen 4242*; Elandshoogte Plantations, *Jacobsen 4772*.

PRE—Blauwberg, Cape, *Leeman 108*; Koegelberg, Cape, v.d. *Merwe s.n.*, Table Mountain, Cape, *Esterhuyzen 15633*; Port Edward, *Strey 8646*; Port Edward, Umtamvuma River, *Nicholson s.n.*; Lusikisiki, *Marais 967*; Kaapsche Hoop, *Wager 85*; Kaapsche Hoop, *Pole-Evans s.n.*; Swaziland, *Compton 26005*; Pilgrims Rest, *Mousse 52*; Mariepskop, *van Son 1751c*; Mariepskop, *Killick & Strey 2389*; Mariepskop, *Meeuse 9862*; Mariepskop, v.d. *Schijff s.n.*; Chimanimani, Rhodesia, 6 000 ft, *Thompson s.n.*; Chimanimani, 5 600 ft, *Mitchell 270*; PRE 2697, sine loc. (very typical).

Forms 1 and 3

While a separation of form 2 from *L. gnidioides* has also been proposed by previous workers, the long stemmed forest form has so far always been considered as a uniform species. As mentioned in the introduction there are, however, two distinct forms. Which of the two represents the typical *L. gnidioides*? Is it the rigid, yellow-green form 1 (Fig. 1, A) or the herbaceous form 3 (Fig. 1, B)? The latter is in some ways similar to the illustration of *L. ophioglossoides* by Schelpe (1970, Table 3) and was initially mistaken for this species by the author. *Marriott* 4878 at PRE was likewise misidentified as this species. Only on comparison with other well authenticated *L. ophioglossoides* at PRE was the difference clearly revealed. The tendency to misidentify the plant indicates that we have here a much frailer form than the stiffly rigid, yellow-green form. Apart from the strong differences in habitus, some observations and measurements show slight differences between the two forms:

	Form 1	Form 3
Leaves:		
Shape	lanceolate	linear-oblong
Tip	acute	rounded
Margin	slightly inrolled	not inrolled
Length mm	12-13	9-15
Width mm	1,5-2,5	2,25-2,5
Sporophylls:		
Spike	3-4 mm diameter	2-3 mm diameter
Shape	ovate-lanceolate	broadly ovate
Tip	acute	acute
Length mm	4-5	2-3,25
Width mm	2	1,75-2
Keel	present	absent

As with *L. gnidioides* var. *pinifolium* the morphological differences could be considered too slight to warrant separation and again the difference in habitus is the decisive factor. The frailer plant cannot be considered as an ecotype as the habitats are the same for both forms. It seems, however, that the rigid form is confined to higher altitudes than the frailer form. A final decision whether the two forms are merely ecotypes cannot be reached at this stage, but could possibly result from experimental cultivation from stem tip cuttings in an atmosphere of high humidity. Such experiments are unfortunately out of reach to the author.

A geographical separation does not seem to exist as specimens of both forms in the author's collection and at PRE originate from a wide range of localities, from the forests of the south-western Cape, through the Ciskei, Transkei, Natal into the eastern Transvaal and from there into tropical Africa.

The following localities for the two forms can be cited:

Author: Erasmus Kop, Transvaal, *Jacobsen 4391*.

Form 2:

Author: Pirie Forest, Eastern Cape, *Jacobsen 4582*; Hogsback Forest, *Jacobsen 4559*; *4560*; Nkandhla, *Jacobsen 4344*; Pilgrims Rest, *Jacobsen 4598*.

PRE—Knysna, *Bottomley s.n.*; Caledon, *Pillans 6342*; Table Mountain, *Marloth 6930*; Pirie Forest, *Sim 1439, 750, 665c, 666c*; Port St. Johns, *Mogg 4667*; Port St. Johns, *McLoughlin 7656*; Port Shepstone, *Strey 5824*; Uvongo, *Strey 821*; Swart Umfolosi, *Codd 1561*; Natal Drakensberg, *Marriott 4878*; Kranskop, *Strey 4243*; Pilgrims Rest, *v.d. Schiiff 6307*; Pisanghoek, Transvaal, *Bosman 3957*; Vulcan Karisimbi, Congo, *Jean Louis 5433*; Reunion, *Schlieben 10867*.

To assist field observations a key for the subdivision of the three forms is supplied.

Stems erect, spikes occasionally

pendulous at the tips Form 2
L. gnidioides L.f.
var. **pinifolium** (Kaulf.)
Pappe & Rawson

Stems pendant

Leaves rigid, coriaceous, adpressed, plant drying yellow-green Form 1
Leaves soft, herbaceous, slightly patent, plant drying dark green Form 3

Asplenium erectum Bory ex Willd.

Some confusion with regard to this species is encountered in the existing literature. It appears as if two rather different forms are described by the same name. Schlechtendal (1825-1832, p. 28, t.15) depicts under this name a fern with fairly large, oblong, falcate, acute, serrate pinnae, but mentions in his description and discussion of the species that there are two forms, one with large pinnae as illustrated, the other with much smaller pinnae, which he interprets as merely immature specimens as transitions exist.

Pappe & Rawson (1858) describe the species as having shortly stalked, lanceolate, sub-falcate, acuminate, bluntly serrate pinnae and refer to Schlechtendal's figure.

Since 1900 descriptions and illustrations of *Asplenium erectum* have been published by Sim, p. 145, t.48 (1915), Tardieu-Blot, p. 219, Fig. XXX, 1-3 (1958) and Schelpe, p. 175, t.53, var. *usambarense* (1970). Sim places the species into the much-varied *Asplenium lunulatum* complex as var. *erectum* (Bory) Sim, while the other two authors refer to it under the name *Asplenium erectum* Bory and *A. erectum* Bory ex Willd. respectively. While Sim's illustration, however, clearly resembles that of Schlechtendal, Tardieu-Blot and Schelpe show a small fern, with small, oblong, rounded, serrate pinnae, quite different from Schlechtendal's and Sim's figures. Schelpe (1967) discusses the variety *usambarense* and finds that the type material from the Mascarene Islands is intermediate between the tropical African var. *usambarense* and the South African plants referred by Sim and others to *A. erectum*. He agrees that a new evaluation of specific and subspecific concepts will have to be done.

When studying collected own material, as also herbarium material at PRE and at the University of Pretoria it was found that there are indeed two well separated forms which in spite of many common features, such as rhizome, the green-winged margins of the greenish-grey rhachis, descrescent pinnae a.o., show considerable differences in total length of frond, as well as in the size and shape of pinnae as the following tabulation demonstrates:

No. of spec. Jacobsen	Length of lamina mm	Length of mid. pinnae mm	Width of mid. pinnae mm	Tip	Origin
3036	300	13	5	round	Vumba
3898	290-350	15-17.5	6-7	round	Chirinda
3124	220	16	6	round	Chirinda
4353	270	12	5	round	Nkandhla
4284	180-190	13-14	4-5	round	Port St Johns
2339	220	16-18	5	acute	Tsitsikamma
4541	440	28-35	9	acuminate	Hogsback
4533	300	23	9	acute	Hogsback
4566	420	42-43	8	acuminate	Hogsback
4452	400	38-40	10	acuminate	Pilgr. Rest
4456	395	38	10	acuminate	Pilgr. Rest
4386	590	32-35	9	acuminate	Pilgr. Rest
4589	585	38-40	10	acuminate	Zoutpansbg.

The difference is also clearly demonstrated on Fig 2, A and B, showing *Jacobsen* 4456 from the Mount Sheba Nature Reserve, Eastern Transvaal with acuminate pinnae of up to 38 mm length and *Jacobsen* 4284 from Port St Johns with rounded to sub-acute pinnae of up to 14 mm length. The longly pinnate form from Hogsback agrees closely with Sim's drawing, t.48

With regard to the length of the fronds Tardieu-Blot seems to have included both forms in her description (200-600 mm), which in turn would explain her inclusion of Sim's illustration into the synonyms although there is a sharp contrast



FIG. 2.

A, *Asplenium erectum* Bory ex Willd. Large-pinna form, Pilgrims Rest District, Eastern Transvaal, Mount Sheba Nature Reserve, *Jacobsen 4456*. Scale in cm; B, *Asplenium erectum* Bory ex Willd. Small-pinna form, Mlolweni Forest, Port St. Johns, *Jacobsen 4284*. Scale in cm.

to her own illustration. It would be interesting to know whether intermediate types occur in Malagassy which seem to be lacking in South Africa.

A distributional separation in South Africa does not exist as both forms have been found in the Woodbush of the eastern Transvaal and in areas as close together as Nkandhla and Qudeni or George and Tsitsikamma.

In view of many common features it seems that both forms should be left in the *Asplenium erectum* complex, but that studies of the original descriptions and types as well as experimental cultivation should be done to reveal whether transitions exist or whether the placing of one or the other of the two forms on to varietal level is justified.

The Genus Polystichum Roth

The following notes should not be considered as an attempt to revise the Southern African species of this notoriously difficult genus, but are designed to help in the understanding and distinction of the various species in Southern Africa. They are based on field and herbarium observations. A key to the presently distinguishable species using simple morphological features is designed, which

includes three clear cut and well authenticated species, two species referred to as sensu their particular authors and one new species.

In the latter instances the question of correct names may ultimately depend on a further study of types and even then the final answer on these difficult and often hybridising species will require cytotaxonomical studies and spore investigations as well as possibly experimental cultivation.

It is felt, however, that pending the conclusion of such detailed studies, the provided key will be of use to separate the various members of the genus in the field. The species as defined are discussed with regard to their salient features and their distribution. The pinnules of the latter three species vary much in size and shape within fairly wide limits and some of these variations are shown on Figures 7, 8 and 9.

KEY TO SPECIES

- 1 Frond pinnate **P. macleaii** (Bak.) Diels
- 1' Frond two-pinnate to three-pinnatifid
- 2 Rhizome, stipe and rachis scales black **P. luctuosum** (Kunze) Moore
- 2' Rhizome, stipe and rachis scales brown
- 3 Sori practically exindusiate or indusia evanescent at a very early stage
- 4 Pinnule margins bluntly crenate **P. zambesiaceum** Schelpe
- 4' Pinnule margins sharply serrate, acute, mucronate or aristate
- **P. transkeiense** Jacobsen
- 3' Sori with more persistent indusia
- 4 Sori reddish-brown, Indusia yellowish, flat, disc shaped plant usually densely set with foxy-red scales, drying green
- **P. setiferum** var. **fuscopaleaceum** sensu Schelpe
- 4' Sori brown, indusia light to dark brown with dark centre, funnel-shaped, plant often set with pale brown scales, plant drying black on upper side and silver to olive-grey on under side
- **P. pungens** sensu Sim

DISCUSSION OF SPECIES

Polystichum macleaii (Bak.) Diels in Nat. Pfl. I, 190 (1899) (wrongly spelt Macleanii); Sim, Ferns S. Afr. 2. ed., 120, t.31 (1915).

Aspidium Macleaii sensu Sim, Ferns of S. Afr. 1. ed., 170 (1892).

This fern with its pinnate, hard, leathery fronds and sharply serrate pinnae is a precise type and offers no problems in South Africa. Sim quotes it from the Transkei (Bazija). The author has seen it mainly in a number of places in the Eastern Transvaal. It has so far not been found further north and is not mentioned in *Flora Zambesiaca*.

Polystichum luctuosum (Kunze) Moore, Ind. Fil.: 95 (1858); Sim, Ferns S. Afr. 2. ed. 117, t.28 (1915); Tardieu, Fl. Madag. Polypod. 1; 320, t.45, Fig. 9-12 (1958); Schelpe, Fl. Zamb. Pterid. 228, t.64, Fig. C (1970).

This is also a well defined and easily recognisable species with its characteristic coat of black to dark brown rhizome, stipe and rachis scales, the longly

tapering apex of the frond (see Fig. 3, A and B), the often falcate pinnae and the oblique and costa-decurrent pinnules.

Its distribution ranges from the Eastern Cape through the Transkei and Natal into the Eastern Transvaal and into Rhodesia, where it is rare. It is also known from Madagascar. It is always confined to deep shade in forests, often growing in ravines or near streams and is on the whole not common.

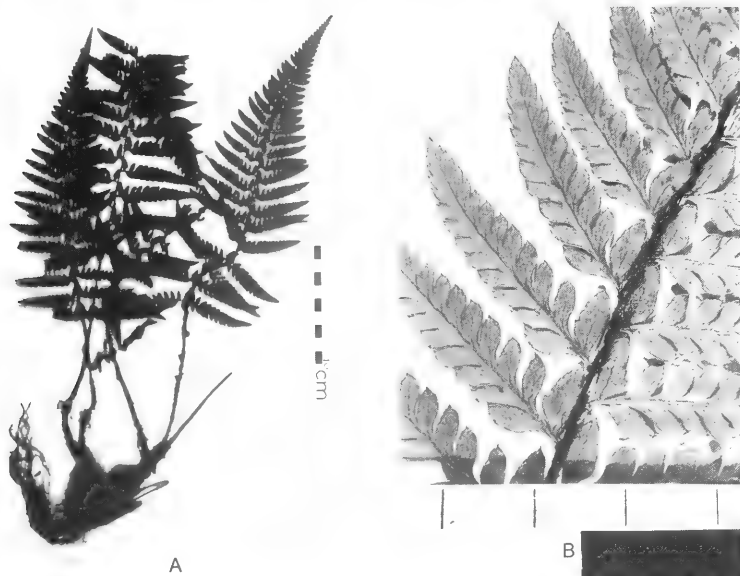


FIG. 3.

A, *Polystichum luctuosum* (Kunze) Moore. Habitus, showing the ovate-lanceolate, attenuate fronds. Blyde River Forest Reserve, Pilgrims Rest District, Eastern Transvaal, Jacobsen 4365. Scale in cm; B, *Polystichum luctuosum* (Kunze) Moore. Centre of lamina. Note the characteristic black scales on the rachis and the acroscopically enlarged basal pinnules. Blyde River Forest Reserve, Pilgrims Rest District, Eastern Transvaal, Jacobsen 4356. Scale in cm.

Polystichum zambesiicum Schelpe in Bol. Soc. Brot., Ser. 2, **41**: 215 (1967); Schelpe, Fl. Zamb. Pterid.: 226, t.64, Fig. A (1970).

This fern, only recently described from Rhodesia, is well characterised by its usually fairly dissected, lobate pinnules with bluntly crenate margins, which separate this species clearly from the following three species, which all have sharply serrate or aristate pinnule margins (Figs 7-9). To Schelpe's clear description the author would like to add some observations on dried material. All specimens seen dried almost black on the dorsal and dull olive green on the

ventral side with slightly darker veins and a slightly chagrined surface. Indusia are obviously evanescent at a very early stage, as they were seen only in one specimen, where they were of half the size of the sorus.

The pinnules vary from almost undivided to pinnatifid (compare Schelpe's illustration in *Flora Zambesiaca*, Table 64, Fig. A₂), are usually triangular with rounded to acute apices, the margins bluntly serrate. The rachis is fairly thin and slightly flexuous with few brown scales, which also may occur on the costae (Fig. 4, A).

Initially there seems to have been some notion that this species was synonymous with *P. ammifolium* Poir. Encycle. 5: 554 (1804) (Schelpe, 1969), although this author (1967) in his annotations to the description of the new species maintains that *P. ammifolium* is apparently endemic to Mauritius. Still earlier Alston & Schelpe (1952), however, regard *P. aculeatum* sensu Sim as synonymous with *P. ammifolium*. Sim's illustration of *P. aculeatum* (t.26), which with its heavy cloth of hair-like scales and its pinnules set at right angles to the costa corresponds best with *P. setiferum* var. *fuscopaleaceum* sensu Schelpe 1970: 226, however, seems to point to the synonymy of the latter two species. Schelpe (1970) accordingly does not quote any synonyms and concludes that the distribution of *P.*



FIG. 10.

Distributions of *Polystichum zambesiacum* and *Polystichum transkeiense*.

zambesiicum is confined to Rhodesia, Malawi and Mozambique. As Fig. 10 shows the species does not occur south of 20° latitude and is separated by a wide distributional gap from the somewhat similar new species *P. transkeiense* as will be discussed below.

The fern is represented in the examined collections by the following specimens:

Author: Imbeza Forest, Penhalonga, Rhodesia, *Jacobsen* 3838, 3838a; Vumba Mountains, Rhodesia, *Jacobsen* 3033, 1454, 3037; Inyanga, Rhodesia, *Jacobsen* 3812.

PRE—Vumba Mountains, *Chase* 1102; Pungwe, *Schweickerdt* 2412.

Whereas the previous three species are well defined and easily recognisable, with only moderate variations in the size and shape of the pinnules, the following three species are sometimes difficult to separate and show great variations in shape and size of pinnules, as Figs 7–9 demonstrate. It is only by extensive studies of herbarium material that the author can now claim to be able to distinguish between the various species in most instances. Least affected by variations is *P. setiferum* var. *fuscopaleaceum* sensu Schelpe which on account of its persistent bright green colour in dried specimens and the abundance of foxy-red to light-brown scales on rhizome, stipe, rhachis and costae is rather easily recognised. The new species *P. transkeiense* usually dries green, but does turn dark on occasions. *P. pungens* sensu Sim always dries black or dark olive green on the upper side and silver grey to light olive green on the under side.

***Polystichum transkeiense* Jacobsen sp. nov.**

Rhizoma elongata repens, paleis pallide vel atro-brunnescentis acuminatis vel caudatis leviter dentatis obsitis. Frondes caespitosi arcuati herbacei. Stipes usque ad 580 mm longus, viridis vel rariter pallide fuscus, glabrus vel ad basim paleis dispersis lanceolatis acuminatis usque ad 13 mm longis obsitis. Lamina 480 mm usque ad maxima 650 mm longa et 300 mm lata, in ambitu ovata acuta, pinnis basalis aliquantum reductis et deflexis bi-pinnatis et leviter vel profunde tripinnatifida. Pinnae anguste oblongae, usque ad 240 mm longae et 60 mm latae ad apicem longe attenuatae et caudatae. Pinnulae petiolatae in ambitu ellipticae vel obliquo-triangulares late acutae, ad basim inaequaliter cuneatae glabrae leviter vel profunde pinnatifidae, lobis serratis acutis vel aristatis, lobo acroscopico basale maximo. Rhachis straminea vel viride tenua flexuosa paleis longis fimbriatis fuscis-castaneis ad basim pinnae concentratis. Sori circulares, c. 1 mm diam., indusium evanidum. Sporangia annulis castaneis transversis striatis et paraphysis atris ad apicem cellulis albis translucis praeditae.

Type: TRANSKEI, (Port St. Johns): 67 m, *Jacobsen* 4301 (PRE).

Also from the following localities:

Author: Mount Sheba Nature Reserve, *Jacobsen 4454*; Qudeni, *Jacobsen 4460*; Nkandhla, *Jacobsen 4355*; Port St. Johns, *Jacobsen 4322*; Hogsback, *Jacobsen 4546*.

PRE—Komati Poort, *Muller 2107*; Qudeni, *Fischer 802*; Buccleuch, Natal, *Sim 3641*; Port Shepstone, *Strey 5994*; Port St. Johns, *Wilkins 40*; Port St. Johns, *Flanagan 2473*; Port St. Johns, *McLoughlin 5/36*; Egossa Forest, *Strey 8869*; Lusikisiki, *Strey 6718*; Visch River, *Zeyher*, coll. *Sim 524c*; Worcester District, *Cooper 1736*; Table Mountain, Cape Town, *Marloth 6936*.

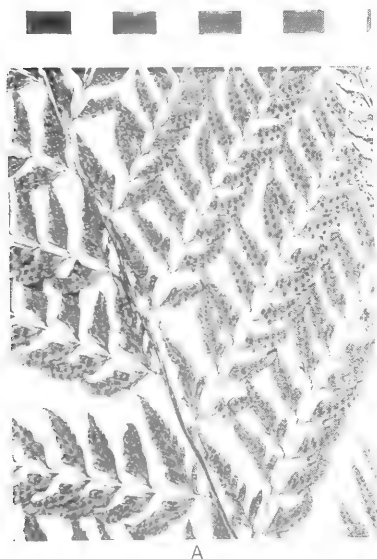
The fern is distinguished from *P. pungens* sensu Sim by its practically exindusiate nature, the softly herbaceous character and its tendency to grow isolated in deep shade and not in large clusters in less shaded positions as is the case with *P. pungens*. From *P. setiferum* var. *fuscopaleaceum* sensu Schelpe it is separated by the scarcity of brown scales, sometimes being practically glabrous and its flexuous thin rhachis (Fig. 4, B and C). From *P. zambesiaceum* Schelpe, which the fern resembles most, it is clearly distinguished by the sharply serrate and usually distinctly aristate or at least mucronate pinnule lobes.

The plant must have been observed by Sim (collected by him at Buccleugh, Natal, under number 3641, PRE) as it occurs quite frequently in Natal and the Transkei, but it is apparently included in his description of *P. aculeatum*, which judging by his illustration on Plate 26 is representative of what is now known as *P. setiferum* var. *fuscopaleaceum* sensu Schelpe.

There are distinct distributional variations, the Natal and Transkei forms having the largest, least scaly fronds and most subdivided pinnules, while the shape of the pinnules of the Hogsback forms tend to resemble *P. pungens* (Fig. 7). The few specimens from the Transvaal are distinctly more scaly and the pinnules are only faintly lobed (Fig. 4, C). The distribution of the species is so far somewhat disjointed, as there are a few gatherings from the southwestern Cape, then a more or less continuous belt from the eastern Cape through the Transkei into Natal and again a few localities in the eastern Transvaal (Fig. 10). These in turn are separated by a wide gap from the similar *P. zambesiaceum* in Rhodesia and Mozambique.

FIG. 4.

A, *Polystichum zambesiaceum* Schelpe. Centre of lamina. Note the strongly divided pinnules with rounded lobes and the thin flexuous rhachis. Vumba Mountains, below Castle Mountain, Rhodesia, *Jacobsen 3033*. Scale in cms; B, *Polystichum transkeiense* Jacobsen sp. nov. Centre of lamina. Similar to A, but lobes sharply serrate-aristate. Note the thin, glabrous, flexuous rhachis. Port St. Johns, *Jacobsen 4301*. Scale in cm; C, *Polystichum transkeiense* Jacobsen sp. nov. Centre of lamina. Undivided pinnules of the Transvaal form, but characteristic is the slightly scaly, thin, flexuous rhachis. Mount Sheba Nature Reserve, Pilgrims Rest District, Eastern Transvaal, *Jacobsen 4454*. Scale in cm.



A



B



C

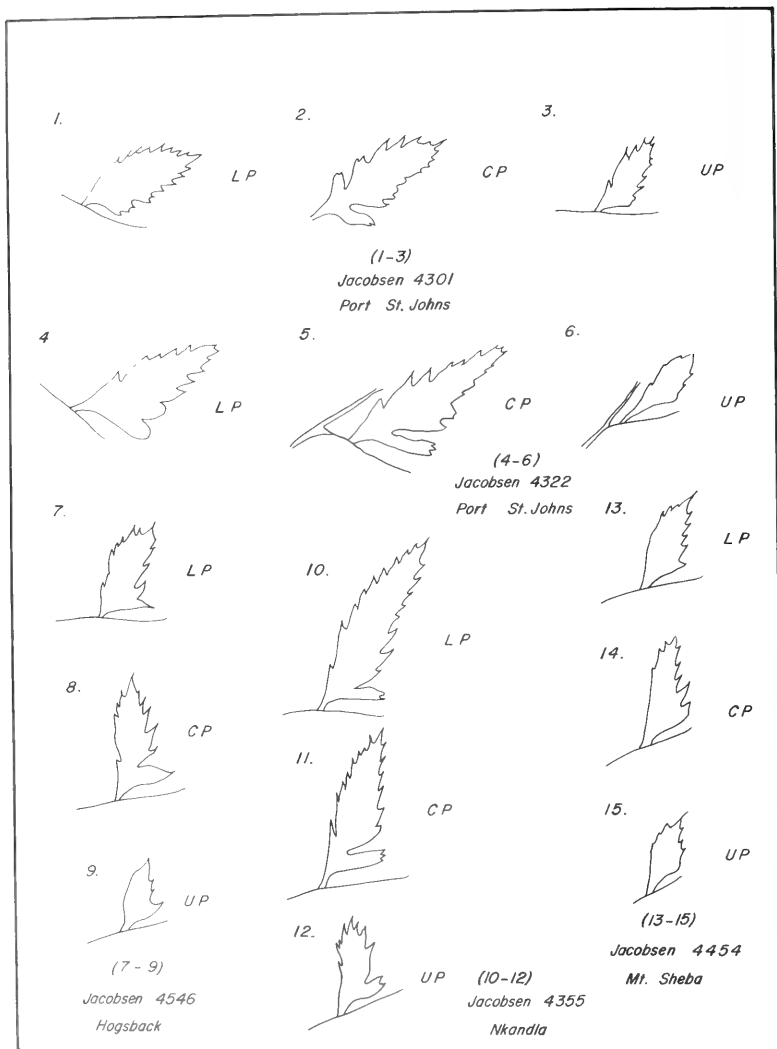


FIG. 7.

Polystichum transkeiense. Variations in size and shape of acroscopic pinnules. Note the sharply serrate and mucronate to aristate character of the pinnule lobes and the strong variations in size of pinnules. Natural size. LP = Lower pinnule, CP = Centre pinnule, UP = Upper pinnule.

Polystichum setiferum* var. *fuscopaleaceum sensu Schelpe in Fl. Zamb. Pterid. 226, t.64, Fig. B (1970).

Polystichum aculeatum sensu Sim in Ferns S. Afr. 2.ed., 115, t.26 (1915).

The likelihood of the synonymy of *P. aculeatum* sensu Sim and *P. setiferum* var. *fuscopaleaceum* has been discussed in the foregoing (see under *P. zambesiacum*). The latter name was published by Schelpe as comb. nov. et stat. nov. *P. setiferum* (Forsk.) Moore ex Woyнар var. *fuscopaleaceum* (Alston) Schelpe in Bolm. Soc. Broteriana Ser. 2, 41: 216 (1967). To avoid ambiguity as to the true nature of the species discussed, however, the author has preferred to refer to the species under the above name.

The fern is fairly easily recognised by its usually heavy coat of light-brown to foxy-red scales on rhizome, stipe, rachises and costae, the almost rectangular setting of the pinnules on the costae and the retention of its green colour when dry. Variation of pinnules in size and shape is not as pronounced as in *P. transkeiense* and *P. pungens* sensu Sim. (Fig. 8).

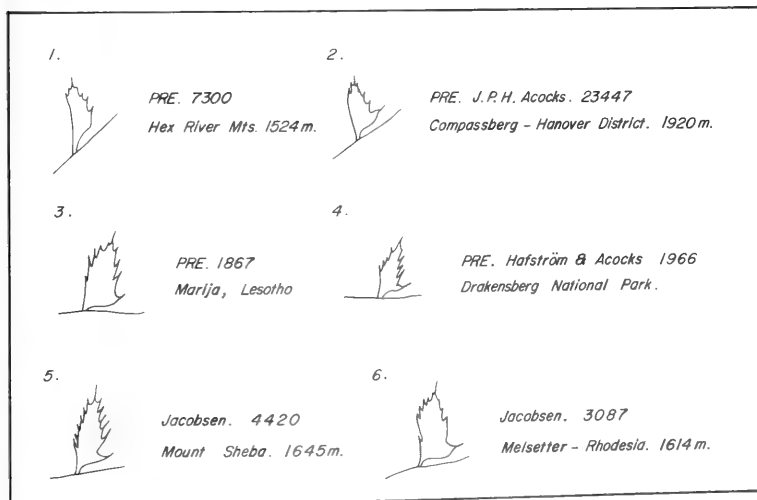


FIG. 8.

Polystichum setiferum var. *fuscopaleaceum*. Variations in size and shape of central acroscopic pinnules. Note the deviation from the usual 90° angle formed between costa and basiscopical side of pinnule in the montane form from the Cape. Natural size. Abbreviations as for Fig. 7.

According to Schelpe (1970) the distribution of the fern is confined to the higher tropical African mountains. A thorough study of the author's material and of material at PRE has extended the range of the species well into the subtropical and even temperate ranges of South Africa, the latter mostly in a slightly diverging

montane form. A comparison of A and B on Fig. 5 as well as the following tabulation proves beyond doubt that the tropical form extends into the Eastern Transvaal.

	<i>Jacobsen 3864</i>	<i>Jacobsen 4485</i>
Locality	Banti South, Rhodesia	Mount Sheba Nature Reserve, Eastern Transvaal
Altitude	1 870 m	1 935 m
Stipe	brown below, stramineous above	brown below, greenish-stramineous above
Stipe scales	large, oblong-lanceolate, acuminate, dark to light brown, 10×3 mm and linear, filiform, smaller, acuminate, light brown	large, oblong-lanceolate, acuminate, dark to light brown, 12×3 mm and linear to filiform, smaller acuminate, light brown
Lamina	arching, herbaceous, 500×200 mm, oblong lanceolate-acuminate, basal pinnae hardly reduced	herbaceous, 580×230 mm, lanceolate, longly acute, basal pinnae hardly reduced
Pinnae	100×23 mm, narrowly oblong, attenuate, basal acroscopic pinnules slightly larger	110×25 mm, narrowly oblong, acute to attenuate, basal acroscopic pinnules slightly larger
Pinnules	closely spaced, slightly petiolate, up to 12×7 mm, cuneate at base, forming a right angle, auriculate acroscopically, oblong, broadly acute, serrate-aristate, glabrous ventrally, softly hairy dorsally	fairly closely spaced, up to 15×6 mm, cuneate at base, forming a right angle, auriculate acroscopically, oblong, broadly acute, sharply serrate-aristate, glabrous ventrally, sparsely pilose to glabrous dorsally
Rhachis	stramineous with numerous reddish-brown, lanceolate to filiform scales on rhachis and costae	stramineous, densely set with reddish-brown linear to hair-like scales with lacinate outgrowths at the base, up to 6 mm long on rhachis and costae
Sori	about 1 mm diameter, indusia fallen off due to mature state	about 1 mm diameter, indusia fallen off due to mature state

It is evident that *Jacobsen 3864* agrees with Schelpe's (1970) description and is, therefore, *P. setiferum* var. *fuscopaleaceum*. With the exception of the almost glabrous pinnules and the slightly larger frond *Jacobsen 4485* (Fig. 5, B) agrees well with No. 3864 and must likewise be considered to be the species. Other gatherings from the Transvaal are *Jacobsen 4428*, a more juvenile specimen, also from Mount Sheba Nature Reserve, where the erose indusia are well preserved,

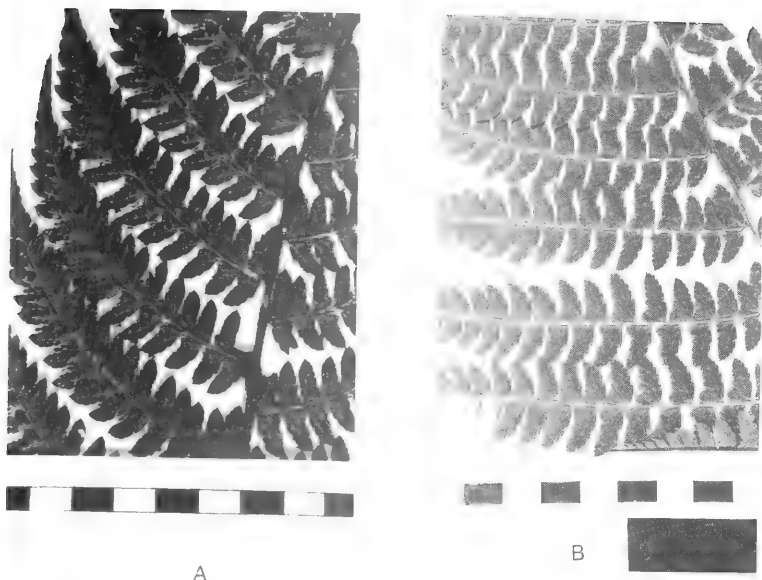


FIG. 5.

A, *Polystichum setiferum* var. *fuscopaleaceum* sensu Schelpe. Centre of lamina. Note the characteristic, almost rectangular setting of the lower edge of the pinnules to the secondary costae. Banti South Endemic Forest, Umtali District, Rhodesia, *Jacobsen* 3864; B, *Polystichum setiferum* var. *fuscopaleaceum* sensu Schelpe. Centre of lamina, showing the typical rectangular setting of the pinnules and the strongly scaly rhachis. Mount Sheba Nature Reserve, Pilgrims Rest District, Eastern Transvaal, *Jacobsen* 4485. Scale in cm.

Jacobsen 4255 from Ohrigstad, 4332 from Mavriestad near Ermelo. *Jacobsen* 4298 from Karkloof in Natal finally extends the range of the species into much lower altitudes (610 m) and further south. A study of the Pretoria material showed gatherings from Mount Hope, Upper Zwart Kei River, 1615 m (*Galpin* 5621) and from Hogsback, Eastern Cape Province, probably from an altitude of 1 160 m (*Dahlstrand* 2902). The range of distribution of the typical form of the species is thus extended into the Eastern Cape Province (see Fig. 11) and into far lower altitudes than was known so far.

The following additional localities of the species are:

Author: Melsetter, *Jacobsen* 3087; Banti South, Rhodesia, *Jacobsen* 3879; Mount Sheba Nature Reserve, *Jacobsen* 4498 and 4420.

PRE—Sabi Gorge, *Wager* 25; Barberton, *Wager* 151; sine loc. PRE 746; Mavriestad, *Polt* 4848; Northern Transvaal, *Repton* 5B; Woodbush, *Reynolds*,

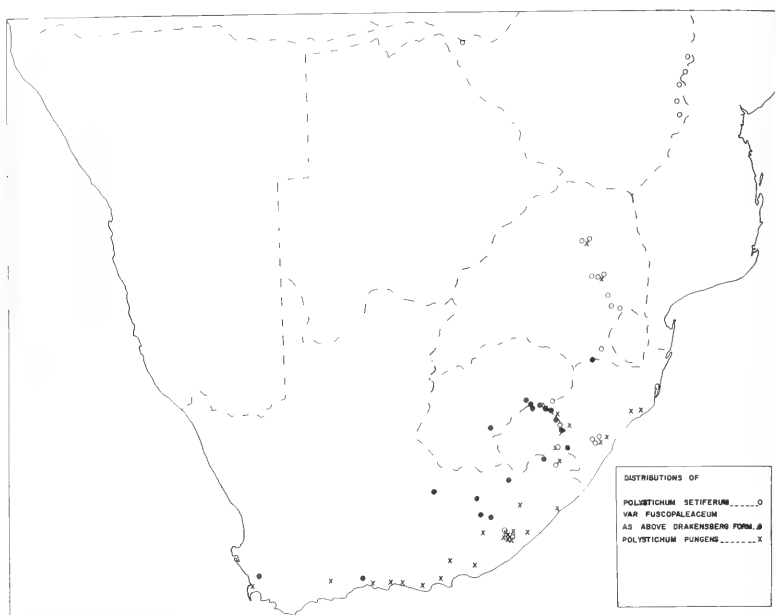


FIG. 11.

Distributions of *Polystichum setiferum* var. *fuscopaleaceum*, its montane form and of *Polystichum pungens*.

PRE 10246; Pilgrims Rest, Collins 895c; Woodbush, Jenkins 919c; Sabie, Wager 48; Duiwelskloof, Scheepers 419; Natal, PRE 2168; Zwartkop, Natal, Sim, PRE 388; Drakensberg, Esterhuyzen 26045; Lion's River, Natal, Moll 829; Cathedral Peak, Killick 1134 and 981 (identified by the collector as *P. setiferum* (Forsk.) Woynar); Natal, Wood, coll. Sim 520c; Van Reenen, Schlechter 42c; Lidgetton, Natal, Roberts 87f; Underberg, Natal, MacClean 684; Tugela Gorge, Hutchinson 41; Lesotho, Dieterlen 695 and 1309; Pirie, East. Province, Sim PRE 3642; Compassberg, Acocks 23447.

While the typical form in most instances loses its indusia at a relatively early stage, although relics may often be preserved, a montane and southern form of the species is characterised by the retention of the indusia well into the mature state. The author refers to this form as the *Drakensberg Form* of the species. Doidge 1061 at PRE shows clearly that the initial stage of the development of the sori commences with the typical flat, disc-like, colourless, erose indusia of the typical form of *P. setiferum* var. *fuscopaleaceum*. The indusia later become mushroom

shaped or slightly funnel-shaped, changing their colour from pale yellow to yellow and reddish-brown, at which stage the likewise reddish-brown sporangia protrude around the margins. Finally the indusia become drawn into the sori which often have tufted white paraphyses. When the sporangia have fallen off an elongated black scar is left along the veins of the pinnules.

The Drakensberg Form is even more densely set with scales than the typical form, having a heavy coat of ovate-lanceolate light-brown to foxy-red scales on rhizome and lower stipe, 12×5 mm in size, with darker brown centre stripe and translucent lighter brown edges. The scales on the rhachis are filiform, foxy red, up to 6 mm long. The frond is narrowly lanceolate, with closely set acuminate pinnae and overlapping pinnules, set at 60° to 90° to the costae, but mostly still revealing the characteristic 90° angle in places.

The persistence of the indusia, the dense cloth of scales and the closely set pinnae and pinnules point to an adaptation to colder climatic conditions, but may also be caused by growth in more exposed, less shady habitats which prevail in the range of distribution of the Drakensberg Form at altitudes from about 1 700 m in the southwestern and southern Cape to more than 2 760 m in the Drakensberg. Specimens have been collected in an area extending from the Hex River Mountains in the southwestern Cape towards the Compassberg and the high portions of the northeastern Cape Province, the Orange Free State, Lesotho and Natal and northwards as far as Wakkerstroom in the southeastern Transvaal (see Fig. 11).

The following gatherings have been made:

PRE—Oshoek, Wakkerstroom District, *Devenish* 2538 and 195; Thaba N'chu Mountain, O.F.S., *Roberts* 2998; Clarence, O.F.S., *van Hoepen* 18230; Mt. Aux Sources, *Bottomley*, PRE 2497; Goodoo, Mt. Aux Sources, *Doidge* 1061; Drakensberg National Park, *Hafstroem & Acocks* 1966; Cathedral Peak, Drakensberg, *Killick* 981 (identified by the collector as *P. setiferum* (Forsk.) Woynar); Giant's Castle, *Snyman* 1281; Cathedral Peak, *Rush* 2030 and 2300; Gudu Forest, Natal National Park, *Edwards* 325; Lesotho, *Schmitz* 402 (identified by the collector as *P. setiferum* (Forsk.) Woynar); Lesotho, *Guillarmod* 690; Lesotho, *Bevis* 102; Molteno, *Flanagan* 1681; Top of Mt. Koudveld, *Herb. Marlothianum* PRE 2170; Highbury, Polela District, Natal, *Doidge* PRE 9; Barkley East, *Galpin* 6934; Matatiele, *Acocks* 12207; Queenstown, Hangklip Mountain, *Roberts* 2012; Compassberg, *Coetzee* PRE 11456; Montague Pass, *Schweickerdt* PRE 4705; Hex River Mountains, *Esterhuysen* 14885.

Polystichum pungens sensu Sim in Ferns S. Afr. 2. ed.: 116, t.27 (1915); *Aspidium aculeatum* Sim in Kaffr. Ferns 46 (pro parte) (1891); *Aspidium aculeatum* var. *pungens* sensu Sim in Ferns S. Afr. 1. ed.: 166 (1892).

This fern is generally referred to in the South African literature (for instance Schelpe, 1952) and herbaria as *P. lucidum* (Burm.) Becherer. The type of this

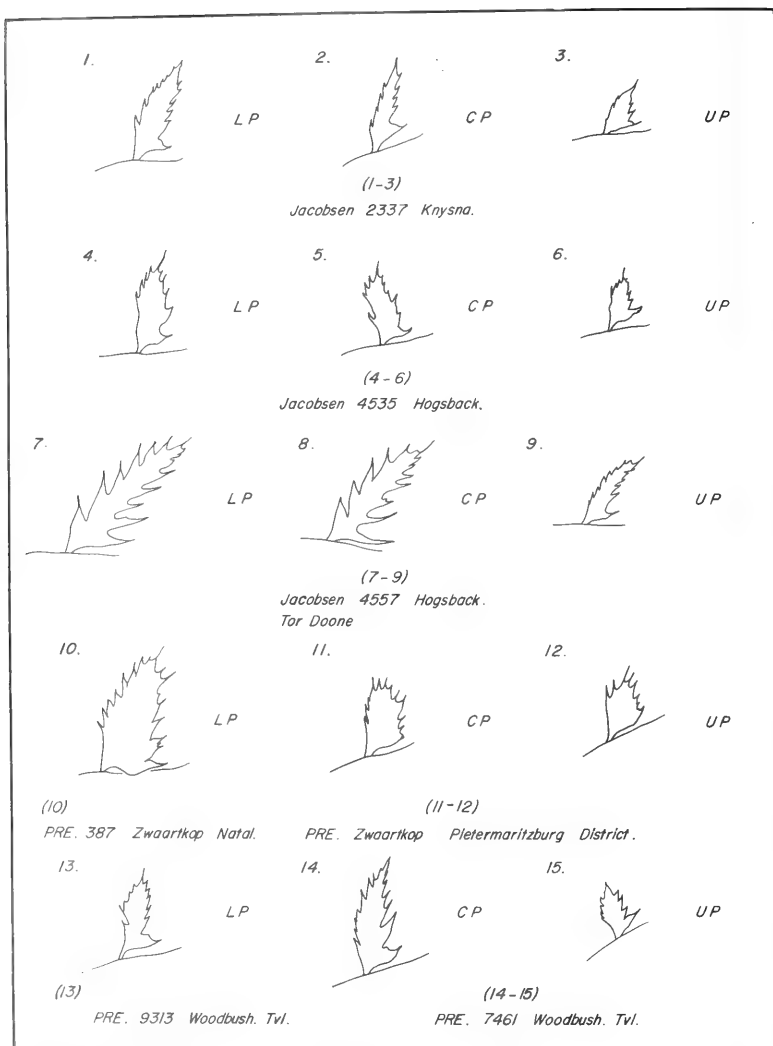


FIG. 9.

Polystichum pungens. Variations in size and shape of acroscopic pinnules. Note the strongly deviating Natal and Tor Doone forms. Natural size. Abbreviations as for Fig. 7.

plant, named *Asplenium lucidum* by Burmann fil. is in Geneva and Becherer gave only a very brief description of it. *Aspidium pungens* Kaulf. was based on a specimen collected by Chamisso in the Cape and is now in Leningrad. As the author is not able to examine either of the types and to avoid confusion as to the plant referred to, it is here quoted as *Polystichum pungens* sensu Sim.

In his description Sim mentions that this fern has given rise to much confusion in the past due to its extreme variability, especially in the size and shape of its pinnules of which Fig. 9 tries to convey an impression. This could possibly lead to the subdivision into a number of forms or even varieties. The author, however, is of the opinion that the varying characteristics are on the whole impersistent in distribution and nature, with the exception of a montane form which will be discussed below.

One of the safest ways of distinguishing *P. pungens* from *P. setiferum* var. *fuscopaleaceum* and *P. transkeiense* in the dried state is the colour, which with *P. pungens* invariably turns blackish or dark olive-green on the upper side and silvery- to olive-grey on the underside. The indusia are practically persistent, peltate, stalked, funnel-shaped, initially colourless to light brown, later dark brown, often with a dark centre, only drawn into the sori at a late stage. The sporangia are brown with a light to dark brown annulus.

The pinnules are strongly varying in size, 13–30 mm long, 6–10 mm wide at the base, their shape varying from non-lobate forms (Natal and Katberg) to strongly subdivided lobate forms (Tor Doone, Hogsback area) as Fig. 9 demonstrates. The typical and most common form of the Cape (Fig. 6, A) has hard, leathery laminae with sharply aculeate pinnule lobes and a heavy coat of yellow-brown to reddish-brown scales on rhizome and lower stipe, which extends to the full length in young fronds. The less typical forms of Natal and Transvaal are not as leathery and more herbaceous.

P. pungens occupies on the whole slightly lower altitudes in the Cape and Natal than *P. setiferum* var. *fuscopaleaceum*. In the Transvaal the fern becomes much less common and is found sporadically in the forests of the eastern Transvaal as far north as the Woodbush. *P. pungens* is the most common fern in the southern Cape and the forests of Kaffraria and assumes in this respect the role which further north is taken up by *Dryopteris inaequalis*. Here it usually forms large clusters, often fully exposed to sunlight above the forests and on top of mountains amongst stones.

The typical form is represented by a great number of specimens:

Author: Mount Sheba, Transvaal, *Jacobsen* 4433; Hogsback, *Jacobsen* 4535, 4553, 4557 (Tor Doone form); Storms River, *Jacobsen* 2331; Knysna, *Jacobsen* 2337; George, *Jacobsen* 2314, 2292, 2317, 2319.



A



B

FIG. 6.

A, *Polystichum pungens* sensu Sim. Right centre pinnae. Note the oblong, falcate, sharply serrate-aristate pinnules. Woodville Forest Reserve, Wilderness, Cape, *Jacobsen 2314*. Scale in cm; B, *Athyrium scandicium* (Willd.) Presl. Caudex, 15 cm high. Mount Sheba Nature Reserve, Pilgrims Rest District, Eastern Transvaal.

PRE—TRANSVAAL: De Hoek Forestry Reserve, *Schweickerdt* PRE 4689; Woodbush, De Hoek, *Schweickerdt* 1852c; Woodbush, *Wager* PRE 7461; Woodbush, *Jenkins* 919.

NATAL: Ngoya, Zululand, *Medley-Wood* 10886 (pinnae undivided, hardly aristate); Zwartkop, *Sim* PRE 3560, 387, 11026, 9259; Drakensberg, *Bottomley* PRE 5018; Pietermaritzburg, *Strey* 8429 (Tor Doone form); Maritzburg, *Sanderson*, coll. *Sim* 530c (Tor Doone form); Eshowe, *Laura* PRE 6421; Winterskloof, *Doidge* PRE 54 (Katberg form).

TRANSKEI AND CAPE: Port St. Johns, *Wager* PRE 2996; Engcobo, Tembuland, *McLoughlin* 1045c; Kentani, *Pegler* 270 (pinnules rather broad, sharply serrate-aristate); Komgha, *Flanagan* 290; Hogsback, *Dahlstrand* 1550, 1853; Pirie, *Sim* PRE 3554; Pirie, *Sim* 533c, 515c (with foxy-red rhizome, stipe and rhachis scales); Pirie, *Sim* 516c (very broad pinnules, but distinctly aculeate and drying black on upper side); Mount Kemp, Pirie, *Sim* 528c; Pirie, *Sim* PRE 3559; Dohne Hill, *Sim* 512c, 513c; Keiskammahoek, *Wells* 3343; Amabele District, *Hardcastle* 293 (small form, with broad, poorly divided pinnules); Frankfort, *Sim* 512c; Katberg, *Young*, coll. *Sim* 518c (with broadly rhomboidal, rectangular based, poorly divided, but strongly aristate pinnules); Zuurberg, *Rogers* 1478c; Albany District, *Cooper* PRE 1161, 1415; Great Winterhoek, *Uitenhage*, *Esterhuysen* PRE 10847; Storms River, *Dahlstrand* 1693; Storms River, *Schlechter* 5963; Knysna, *Marloth* 5711; Knysna, *Rex* 840c, 838c (Tor Doone form, with dense foxy-red scales on rhachis); Plettenberg Bay, *Rodin* 1191; George, *Schlechter* 525; Wilderness, *Mogg* 11636; Ladysmith, *Esterhuysen* 14013; Hofmansbosch, *Britten* PRE 4241; Cape Town, *Marloth* 541 (very large pinnules, sharply serrate, aristate); Table Mountain, *Esterhuysen* 15355 (Tor Doone form).

Similar to *P. setiferum* var. *fuscopaleaceum*, *P. pungens* has developed a high altitude *montane form* which may be distinguished from the typical form by the almost total lack of scales on rhachis, costae and costulae. The lower part of the stipe bears a cloth of dark reddish-brown linear to lanceolate scales. The texture of the lamina is thick and leathery, drying in contrast to the typical form to a fairly even matt olive-green on both sides. The pinnules may be aculeate, but are more often only coarsely serrate without the usual bristle points of the common form.

Representative specimens are:

PRE—Tabanhllope Mountain, Natal, *Wisch* 184; Tugela Valley, *Hafstroem & Acocks* 1970; Mont Aux Sources, *Schweickerdt* 760; Cathedral Peak, *Esterhuysen* 10199a; Cathedral Peak, *Edwards* 851; Rokerries Pass, Drakensberg, *Edwards* 2145; Golden Gate Highlands Park, O.F.S., *Liebenberg* 7498.

The Dryopteris inaequalis Complex.

Schelpé (1970, p. 221) describes *Dryopteris inaequalis* (Schlechtendal) Kuntze as a fairly large fern with creeping rhizome, large pale brown rhizome scales, a

long stipe, a large, broadly to narrowly ovate, triangular, two-pinnatifid lamina with the basal pinnae hardly or not reduced. While this description fits the most common forest fern in Southern Africa, the author observed and collected a similar, but much smaller fern in various forest localities which differs from *D. inaequalis* sensu Schelpe in its present concept by its non-triangular, broadly lanceolate frond and its distinctly reduced basal pinnae. While the large fern is usually 3- to 4-pinnatifid (not always 2-pinnatifid as Schelpe's description of the Rhodesian form confusingly seems to convey), the small fern is never more than 2-pinnate to 3-pinnatifid. Its characteristics seem to agree well with the description of *Dryopteris inaequalis* sensu Sim (1915, p. 106, t.18); while the characteristics of Schelpe's *D. inaequalis* are coinciding with *D. elongata* sensu Sim (1915, p. 104, t.7). The history of the synonymy of the two species seems to contain a certain amount of confusion until 1964, as Table 1 demonstrates.

It is obvious that Schelpe in his later publications, combined the two species in one which he considered to be *D. inaequalis* (Schlechtend.) Kuntze, thus disregarding that this name referred to the small and relatively rare species of Sim (1915) and that *D. elongata* sensu Sim, corresponded with the common large forest fern. He must have come to the conclusion that the two species were not sufficiently distinct to be separated. Sim admits that there may be confusion between the two species when young. This was also observed by Burtt-Davy (1926) and the author. But in all instances where adult material is present, the distinction is easy. The author collected the small species in the Wilderness and the Hogsback and Pirie Forests. It is clearly distinct from the tall, triangular fronds of the common large fern by its very pronounced creeping and unusually thick (for such small fern) rhizome, its lanceolate fronds with widely separated pinnae, of which the basal pair is always smaller than the one above (Fig. 1, D), thus contrasting sharply with the distinctly triangular fronds of the larger fern, where the lowermost pinnae are always the largest. The author also had no difficulty in separating the relatively few specimens of the smaller fern from the several hundred specimens of the *D. inaequalis* complex at PRE, provided the entire frond and possibly the rhizome are preserved.

The following specimens were recognised to belong to this type:

Author: Hogsback, *Jacobsen* 4576, 4571; Pirie, *Jacobsen* 4584; George, *Jacobsen* 2318.

PRE—Mooi River, Natal, *Mogg* 2160; Zwartkop, Natal, *Sim* PRE 3624; Frankfort, Cape, *Sim* 480c; Pirie, *Sim* 469c; Wilderness, *Mogg* 11775; Keiskammahoek, *Kotsokoane* 246; Woodvale Forest, Queenstown District, *Galpin* 8202 (determined by Schelpe as *D. inaequalis* (Schl.) O. Ktze. and thought to be intermediate with *D. elongata*); Ravine, 9½ miles up Kowie River, *Bosman* PRE 2968; sine loc., PRE 2295; sine loc., *Wells* 3339; Kookfontein, *Burger* 961c.

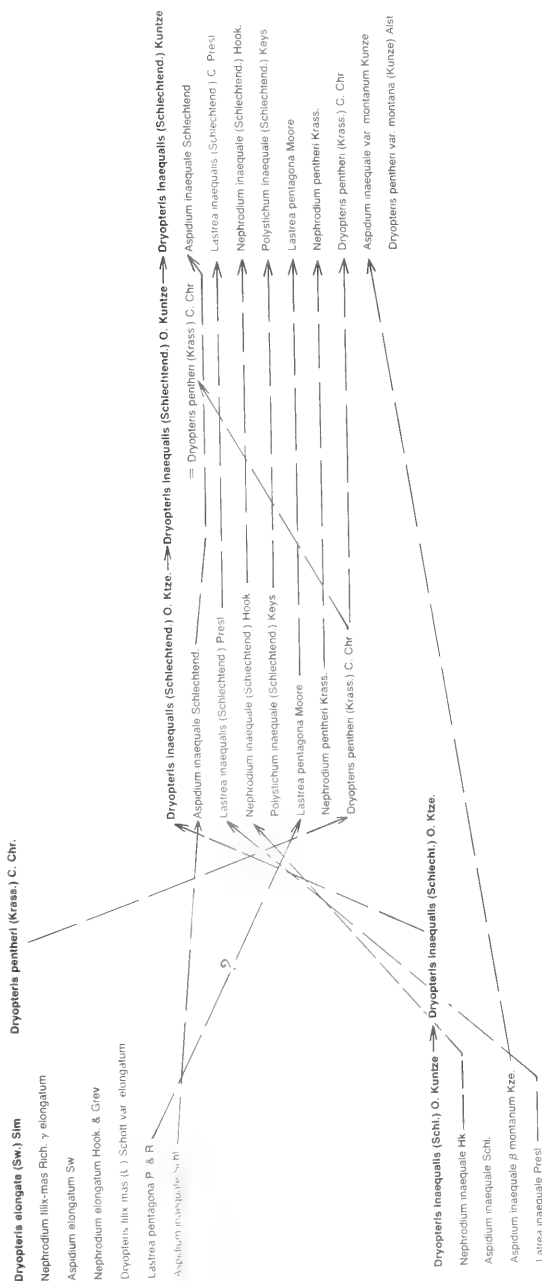
Table 1
Sim 1915

Schelpe 1970

Schelpe 1969

Schelpe 1964

Schelpe 1952



It appears therefore, as if the re-institution of the previous subdivision into two different types may be justified, and that a clarification of the nomenclature and status of the two forms is called for.

The distribution of the smaller fern is quite interesting as it seems to be confined to a relatively low altitude belt, extending from the Wilderness over the forests of the Eastern Cape Province to Natal. Sim, in addition, quotes it from the Swellendam area, which appears feasible, but also from the Northern Transvaal (Woodbush) and Rhodesia as well as Mozambique. There are, however, no records from these areas at PRE. The altitude seems confined to the span from sea level to 1 220 m. The habitat requirements are deep shade, either in herbless ravines and gullies or, as frequently in the Hogsback and Pirie Forests, under a dense herb layer and then extremely difficult to find. The plant may therefore not be as rare as stated, but merely overlooked. The large form is common on forest floors throughout Southern Africa, but is also found in fairly open ground, at forest edges or on granite hills in Rhodesia, in which instances the pinnule lobes tend to become narrower and the pinnae are slightly wider spaced.

Athyrium scandicinium (Willd.) Presl

Schelpe, *Flora Zambesiaca*, 1970, uses as one of the distinguishing features between the genera *Athyrium* and *Diplazium* the absence, respectively presence of a caudex. Although in most instances applicable it was found that *Athyrium scandicinium* may develop a distinct caudex (Fig. 6, B). The author saw this species in the Mount Sheba Nature Reserve, Pilgrims Rest District, in a streambed on the so-called "Sheba Trail", shortly before this emerges from the forest into open grassland. About four or five specimens are growing here in a cluster on large boulders of quartzite, having caudices from 50 to 150 mm height from which large tufted fronds of about 600 mm length and 230 mm width emerge. The caudices are between 30 and 40 mm thick. The thick erect rhizome or caudex and the merely slightly incised pinnule lobes identify the species as *A. scandicinium*, as the similar *A. schimperi* has a creeping rhizome and strongly and deeply incised pinnule lobes.

References to this unusual habitus could not be found in the corresponding literature. Sim (1915) speaks merely of a suberect paleaceous crown. Tardieu-Blot (1958) quotes an erect rhizome and tufted fronds. More precise statements are found in Schelpe (1970): "Rhizome up to 5 mm in diameter, erect, with tufted fronds and oblong etc. rhizome scales". Yet in 1956 Schelpe collected his No. 6002 (PRE) at Entabeni in the Zoutpansberg with the annotation "Rhizome erect and massive". This is apparently a similar tall specimen with fronds of 650 mm length and approximately 300 mm width. From the use of the expression "massive" the author concludes that this may well have been a plant with a small caudex. Schelpe's key in *Flora Zambesiaca*, therefore, may thus be restricted to tropical Africa (Rhodesia, Malawi, Mozambique), but loses its validity further

south. This geographical restriction seems to point to the possibility that the development of a caudex by *A. scandicinum* may be due to climatic factors and may take place only in the cool to cold montane forests of the Transvaal and possibly further south? The species extends in its distribution to Natal, but here usually at lower altitudes. Sim (1915) reports it also from Grahamstown and from Lesotho. Specimens from the latter locality might be interesting, but are unfortunately not represented at PRE.

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation and thanks for the valuable assistance received from the Director of the Botanical Research Institute, Pretoria, Dr. B. de Winter, as well as from Mr. P. Vorster, Botanist in charge of the Cryptogam Section of the same institute.

Thanks are also due to Prof. P. J. Robbertse of the University of Pretoria for permission to study herbarium material at the Department of Botany.

Finally, the author would like to thank the Directors of Nature Conservation in the Transvaal, Natal and the Cape Province for the permission to collect Pteridophyta at various periods through the last years and especially Mr. N. Jacobsen of the Department of Nature Conservation of the Transvaal who during his work in various Nature Reserves collected many interesting specimens for the author's use.

REFERENCES

- ALSTON, A. H. G. and SCHELPE, E. A. C. L. E., 1952. An annotated check-list of the Pteridophyta of Southern Africa. *Jl S. Afr. Bot.* **18**: 153-176.
- BAKER, J. G., 1887. *Handbook of the fern allies*. London.
- BURTT-DAVY, J., 1926. *A manual of the flowering plants and ferns of the Transvaal with Swaziland, South Africa*. London.
- PAPPE, L. and RAWSON, R. W., 1858. *Synopsis Filicum Africae Australis*. Cape Town.
- SCHELPE, E. A. C. L. E., 1967. New taxa of Pteridophyta from South East Tropical Africa. *Bolm Soc. broteriana* Ser. 2, **41**: 203-217.
- SCHELPE, E. A. C. L. E., 1969. A revised check-list of the Pteridophyta of Southern Africa. *Jl S. Afr. Bot.* **35** (2): 127-140.
- SCHELPE, E. A. C. L. E., 1970. Pteridophyta. In: A. W. Exell and E. Launert, *Flora Zambesiaca*. London.
- SCHLECHTENDAL, F. L. de, 1825-1832. *Adumbratio Filicum in Promontorio Bonae Spei Provenientum*. Berlin.
- SIM, T. R., 1915. *The Ferns of South Africa*. 2nd ed. Cambridge.
- TARDIEU-BLOT, M. L., 1958. Polypodiacees (sensu lato). In: H. Humbert, *Flore de Madagascar et des Comores*. Paris.
- TARDIEU-BLOT, M. L., 1971. Lycopodiacees, Huperziacees. In: J. F. Leroy, *Flore de Madagascar et des Comores*. Paris.

“DRIFT SEEDS” AND “DEAR DIRTY DUBLIN”: CORRESPONDENCE BETWEEN JOHN MUIR AND MATILDA C. KNOWLES, 1930–1933

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ABSTRACT

Between 1930 and 1933, Dr John Muir of Riversdale, corresponded with Miss M. C. Knowles, botanist in the National Museum of Ireland, Dublin, about drift seeds. Their letters, published herein, reveal some of the problems faced by Muir in his research on alien beach drift, and the extent of the assistance he received from Dublin.

UITTREKSEL

“DRIFT SEEDS” EN “DEAR DIRTY DUBLIN”: BRIEFWISSELING TUSSEN JOHN MUIR EN MATILDA C. KNOWLES, 1930–1933

Tussen 1930 en 1933 het Dr John Muir van Riversdal briewe met Mej. M. C. Knowles, plantkundige aan die Nasionale Museum van Ierland, Dublin, gewissel oor dryfseed. Hulle briewe onthul sommige van die probleme waarmee Muir te doen gekry het in sy studie van uitheemse opdrifseeds en die hulp wat hy van Dublin ontvang het.

INTRODUCTION

One of the most important contributions to research on long-range dispersal of plant propagules by ocean currents was made by Dr John Muir, who carried out a very detailed and extensive survey of alien fruits and seeds in the beach drift of southern Africa.

John Muir (1874–1947) was born in Scotland and qualified as a doctor of medicine at the University of Edinburgh in 1896. In the same year he emigrated to South Africa where he practised medicine for nearly thirty years. Muir eventually settled in Riversdale, and after retiring from medical practice in 1923, he concentrated on botanical research. As a medical practitioner, Muir worked on haemophilia, and according to one of his letters to Miss Knowles (see below), he spent two months at the Coombe Hospital in Dublin in 1910.

Muir's botanical research was wide-ranging, and gained him honorary doctorates from the Universities of Edinburgh and Stellenbosch. However, his interests also included sea-shells, ornithology, genealogy, folk-lore and he collected the vernacular names of plants, shells, and birds in the Riversdale region (see Hopkins, 1972; van Blerk, 1972).

In their recently published work on tropical drift fruits and seeds, Gunn & Dennis (1976) said that without Muir's studies the beach drift of Africa “would be

virtually unknown''. Muir visited beaches on the Mozambique, Congo and Cameroon coasts, as well as those in South Africa (Gunn & Dennis, 1976). He made extensive collections of "drift seeds", which are preserved in the University of Stellenbosch (STE-U), and he obtained seeds from living plants to aid identification of the beach collections. Muir published his data in a series of scientific papers and popular articles (e.g. Muir, 1929a, 1929b, 1931a, 1931b, 1932, 1934, 1937).

CORRESPONDENCE WITH DUBLIN

A major problem faced by research workers studying "drift seeds" is the identification of specimens, which is intensified as the "seeds" are not attached to plants whose characters could aid identification. The disseminules of genera of Leguminosae especially are difficult to identify to species level (Gunn & Dennis, 1976). Muir's correspondence with Dublin arose from his need for assistance with the identification of his specimens.

It seems, from extant letters, that Muir first wrote to Ireland in order to get a copy of a paper published by Nathaniel Colgan (1919) on Irish "drift seeds". This first letter probably was addressed to Dr. R. L. Praeger, the leading Irish botanist at that time, and Praeger sent a copy of the paper to Muir; this letter is not extant. The earliest surviving letter, written by Muir to Praeger, thanks Praeger for the Colgan paper, and requests assistance with identification.

In 1915, Dr H. B. Guppy who was studying tropical "drift seeds" (see Guppy, 1917) presented to the National Museum of Ireland a collection of seeds and fruits of West Indian plants whose propagules were recorded from beach drift in the British Isles as well as "seeds and fruits . . . that have not yet been recorded from the beaches of the United Kingdom though it is likely that some of them have been picked up but have not been identified"¹. Guppy hoped that this collection "though not a large collection . . . (would) be of a little service in directing once again the attention of botanists in Ireland to this subject"². Guppy (1917) noted that he had presented this collection to Dublin, as did Colgan (1919).

Muir's letter requesting identification assistance was passed to Miss Knowles, the "Lady Assistant" in charge of the museum's botanical collections. Miss Knowles studied the specimens sent in by Muir, and sent him a set of notes on the material after she had compared the seeds with those in Guppy's collection. In his reply thanking Miss Knowles for her aid, Muir complained that Kew had not given any help, even though there was a very large collection of "drift seeds" in the Royal Botanic Gardens. Undoubtedly, Muir was very grateful for the assistance given by Miss Knowles, and the friendly though sporadic correspondence that continued until 1933 clearly indicates the rapport that arose between Dublin and Riversdale.

In gratitude for Miss Knowles' help, Muir sent to Dublin a small collection of seeds and fruit, both beach drift and fresh specimens. These specimens are

preserved in the herbarium of the National Botanic Gardens, Glasnevin (DBN) along with Muir’s letter and some rough drafts of Miss Knowles’ replies; the botanical collections of the National Museum were transferred to the National Botanic Gardens in 1970. Muir also sent offprints of some of his papers and articles; these are also held in Glasnevin. As noted, Muir’s own collection of “drift seeds” is preserved in the University of Stellenbosch (STE-U), along with letters from Muir’s correspondents, including Miss Knowles; no letters from Dr Praeger are preserved in Stellenbosch (Jordaan, pers. comm.), though perhaps none was written.

Miss Knowles’ last letter to Muir, thanking him for an offprint of one of his papers (Muir, 1932) was written a few weeks before she died after a short illness (Praeger, 1949).

THE LETTERS

The letters are published in chronological order, and are printed in full; some of the rough drafts included in the Glasnevin archives are not included. Copies of Miss Knowles’ letters (originals in STE-U) have been placed in the Glasnevin archives, and copies of Muir’s letters (originals in DBN) are available in the University of Stellenbosch.

This first letter was written to Dr Praeger; it was passed by Praeger to Miss Knowles and therefore is preserved with this correspondence.

The original spelling and punctuation of the letters are retained in this paper.

“Leeuwarden”
Riversdale
2 June 1930

Dr John Muir
(M.B., D.Sc.)

Dear Mr Lloyd Praeger,

Very many thanks for the valuable paper by Mr Nathaniel Colgan³ on the larger alien Irish Beach Drift. I am only sorry that I cannot consult Dr Guppy who passed away in 1926. I have been unable to get a single seed named, although the Buitenzorg people in Java sent me a nice lot of cultivated seeds and fruits.

I have just found that *Barringtonia speciosa*⁴ reaches here.

I am venturing to send you a few seeds and would be very grateful if you would have them compared with Guppy’s which he gave to the National Irish collection. If you will return them to me I wd. send some to you later if they wd. be acceptable.

352:83⁵ Kew named these near *Entada* sp. but they are *Azelia bijuga* [= *Intsia bijuga*] I feel sure. They grow when sown and the leaves are not quite the same as *Intsia bijuga* from Madagascar, or the seeds are larger than those I have seen from Calcutta and the Philippines. Still I am nearly certain.

171.40. These must be *Dioclea* sp. Did Guppy give you anything like these?

255.373. These I think must be *Strongylodon ruber* (*lucidas*)? Do they resemble any form of *Mucuna urens* known to you? Is the cosmopolitan polyzoon on 255 *Membrani-*

pora? No one in S. Africa knows it. If so Mr Colgan has solved one of my difficulties for me. They may be *Mucuna* sp.

36. Must be *Dioclea reflexa*: black form

324. Must be *Dioclea reflexa*: brown form

445, 443, 26, 314: various types of *Mucuna* spp unknown to me and everyone I have consulted.

*Entada scandens*⁶ and *Caesalpinia Bonducella (crista)*⁷ as being abundant and well known I have not sent nor the usual Rhizophoraceae and other mangroves.

All were picked up here. If you care to lecture on them I have not the slightest objection, senders rights protected.

I know all the seeds mentioned by Mr Colgan, as I have *Sacoglottis* from Trinidad.

With Kind regards, I remain

Yours sincerely

John Muir.

They must all come from Madagascar, Malaya or E. Indies. None are African.

A note, in pen, is written on the first page and reads "Seeds returned & notes on comparisons with those in our collection. July 4. 1930 MCK".

Ard-Mhusaeum Na h-Eireann
(National Museum of Ireland)
Sraid Chill Dara
(Kildare Street)
Baile Atha Cliath
(Dublin)

July 4 1930

Dear Dr Muir,

As Dr Lloyd Praeger was leaving Dublin for some weeks when your letter & box of drift seeds arrived he passed these on to me and asked me to make the comparison with the drift seeds in our collections and let you know the result. As Dr Praeger has probably told you our collection is a small one composed almost entirely of the seeds that reach our Irish shores. These have however all been vouched for by either Mr Colgan or Dr Guppy, so although our collection is a very limited one it is reliable so far as it goes.

It has been very interesting to compare your seeds with ours but I am afraid you will find the results very disappointing. I have made a few notes on a separate sheet [see below]. It will be a satisfaction to you to find that your *Membranipora* on No. 255 is *M. tuberculata*. I sent the seed to Mr Farran of the Department of Fisheries and enclose his note about it which you need not trouble to return⁸. I also showed it to Mr Nicholls who used to be keeper of the Natural History Collections here & who specialized in this group and he too considers it "almost certainly" *Membranipora tuberculata*. I am indeed very sorry and disappointed that our collection has not proved more helpful in solving your difficulties. The seeds of these Leguminous climbers seem to vary a good deal even in the same species which makes the identification troublesome & uncertain.

Dr Guppy was a great loss. I wonder where his collection went to?⁹ I should have expected Kew to get it, but it may have gone to the Natural History Museum, South Kensington, London. Mr Ramsbottom is the present Keeper of the Botanical Collections

there & would I am sure help you in any way he could if you wrote to him. Dr Rendle retired a few years ago.

I am returning your seeds as requested & hope they will reach you safely.

With best wishes
Yours sincerely
Matilda C. Knowles
Assist. in charge of the
Botanical Collections

P.S. It is very kind of you to offer us some seeds & we should be most grateful for any you can spare us.

A rough draft of the notes on Muir's seeds in Miss Knowles' writing is preserved in DBN; it is printed here. Corrections to the notes have been edited into their correct places in the text.

Drift seeds—South African—from Dr Muir

353.83. We have nothing at all like these in our drift collection. I have also looked up *Azelia* in our Herbarium as sometimes there are seed samples attached, but our only species is *A. Africana*. *A. bijuga* probably belongs to the section with no arillies.

171.40 We have one mottled seed similar to these but rather larger & thicker in tone, with a darker raphe. Guppy labelled this *Dioclea reflexa*. Your seeds agree very well with his description of the seeds of this species in "Plants, Seeds and Currents" p. 131 and no. 40 though slightly smaller is similar in shape to fig. 6. in the plate at the beginning of this book.

255, 273 These are not exactly like any seeds of *Mucuna urens* in our collection, they are smaller & the raphe does not encircle the seed so much as in our samples of *Mucuna* but more than in *Strongylodon* or *Dioclea* according to the descr. in *Genera Plantarum* of these genera. They are rather like two seeds amongst those Guppy gave us labelled "*Dioclea* (probably) *gutanensis*" except for being a little less round (but they seem to me to be too round for *Dioclea*¹⁰). I do not know *Strongylodon* but the hilum is described in *Genera Plantarum* as being *semicircata* while these are more than $\frac{3}{4}$. Mr Farran of the Fisheries Department thinks the polyzoon encrusting No. 255 is *Membranipora tuberculata*.

36, 324 are very like *Dioclea reflexa*. They are rather flatter than our specimens and 36 is more oblong in shape otherwise similar. There is one seed that is identical in every respect with your number 324 (and one or two other very similar) amongst a sample of drift seeds we have from Keeling or Cocos Island¹¹, given us many years ago by the then Director of Kew Gardens and labelled "*Mucuna* sp." There are a number of undoubted *Mucuna* seeds in the sample but those similar to your 36 are more like *Dioclea reflexa* I think.

443 We have nothing like¹²

26 We have nothing like this

314 "

445 more like "*Dioclea*" than "*Mucuna*" I should say¹³

Miss Knowles returned Muir's seeds to him and received the following letter.

29 July 1930

Dear Miss Knowles,

Your letter of July 4th is just about the most helpful communication I have ever received during two years work at the alien and local Beach Drift. Mr N. E. Brown, a very old friend, wrote by the same mail and I hear from him nearly every week. He says that the collection of beach drift at Kew is immense but that no one ever works at it.

Kew did not name a single one of my species and were not one tenth as helpful as you with your small collections.

Please thank Mr Farran for naming the *Membranipora*.

This is just a short note of thanks and to give you a piece of what to me is important news.

My 352 & 83 which you write about as follows "We have nothing at all like these in our collections" and named at Kew "near *Entada*" is *Afzelia bijuga* A. Gray (= *Intsia bijuga*) I received seeds from the French authorities at Madagascar ten days after I wrote to you. You will see much about them in Guppy's "Nat. Pacific" II¹⁴. They have not before been found in the beach drift of other tropic regions (ib. 174). The Riversdale beach is temperate and my seeds which are washed up come almost entirely from Madagascar. I have pleasure in presenting you with one of each.

I agree with you entirely that my 36 and 324 (the latter identical you say with one of Guppys from the Cocos Islands named at Kew *Mucuna* sp.) is *Dioclea* & not *Mucuna*. I cut them open & they have no intercotyledonary cavity. The kernal floats independently of the testa for some time, & they belong to the Sect II of the group of non adaptive seeds (*Nat. Pac.* II 107). Do you remember which one in your collection is= my 324 (unspotted, dark brown)?

I am also sending you a short paper on the Folk Lore of these seeds¹⁵. *Ent. scandens* & *Caesalp. Bonducella* grow in Port. East Africa. I have a pod of the former 37" long, and the prickly pod of the latter.

I have been working through Schimpers "Die Indo-Malayisch Strandflora"¹⁶, a rare book now a days which took me a year to get. Guppys paper in *Journ. of Vict. Instit.* in the Keelings has so far eluded me¹⁷. I was glad to get Colgan's fine paper.

It is fine to see your name in Guppys *P.S. and C.*, & to receive a letter from some one who knew Guppy which I never did¹⁸.

In 1910 I had two months at the Coombe Hosp. Dublin & spent one of the happiest times of my life in that unsavoury although in other respects delightful surroundings. My recollections of Ireland have always been of the pleasantest.

Some of my seeds have gone to Madagascar, Mauritius & Calcutta.

Calcutta seeds of *Afzelia bijuga* & one lent me by Kew from Luzon agree; but they are much less massive than the Madagascar ones. Either more than one species is included under that name, & the genus requires revision, or it varies enormously.

I will send duplicates of seeds later, if Calcutta or Antananarivo¹⁹ recognise them.

With best wishes

I remain, Yrs sincerely
John Muir

Dublin. August 27 1930

Dear Dr Muir

I am just going off for my belated summer holiday but I must send you a few lines before I go to thank you for your very kind letter of July 29th & for the valuable additions to our Drift Seed Collection which arrived safely a few days ago.

I am delighted to get the two seeds of *Afzelia bijuga*, one from Madagascar & one from the Riversdale coast & also the two samples of *Scaveola* (sic)²⁰ & I think it is most awfully good of you to have rewarded my small efforts so generously. I shall incorporate them in our Drift Seed Collection on my return²¹ & I am sure some worker at the subject will one day bless you. Accurately named specimens are not easy to get.

I wish Guppy had lived to know that you have become so interested in this fascinating but difficult & tedious question of the Drift Seeds. It is such a help & stimulation to have a fellow enthusiast to discuss ones problems with. I did not know him personally—only through correspondence.

I shall pass on your message to Mr Farran on the first opportunity I am sure he will be glad to know he has been of use.

Dr Praeger looked in here yesterday & was asking for you. He is just back from the Botanical Congress at Cambridge where they had a very busy week over the revision of the Rules of Nomenclature, which they seem to have settled satisfactorily. He was much pleased to learn that Colgan's paper had proved of interest to you. I have promised him the loan of your paper on the Folk Lore of *Entada* & *Caesalpinia*²².

You will have to come over & work out the Drift seeds at Kew yourself & if so you will probably run across and renew your acquaintance with "dear dirty Dublin" & pay us a visit here. I should enjoy going through our collection with you.

With renewed thanks & apologies for this scrappy letter. I am yours sincerely

Matilda C Knowles²³

P.S. I made a note of the seed I thought like your no 324²⁴

Riversdale 19.8.1930

Dear Miss Knowles

Guppy's paper "Dispersal of Plants as illustrated by the Flora of Keeling Atoll." *Journ. of Vict. Inst. Lond.* 1889 (1890) is unobtainable in S.Afr. and I have not yet got it from Edinburgh or London. Is it very long? If not cd. you have a precis made by one of your staff in exchange for seeds? I can send you

Canavalia obtusifolia

Ipomoea pes-caprae (fresh and from drift)

A pod of *Caesalpinia Bonducella* with its two seeds in situ

Strongylodon lucidus (= *ruber*), named since I received your letter at Calcutta, confirming my suspicions. They are the seeds of mine that you saw (see Guppy *Nat. Pac.* II).

Please note for your private information that my seed 324, which you say = one of Guppy from the Keeling Atoll in your possession, named *Mucuna*, but which I said is *Dioclea*, is now named by the Calcutta people *Dioclea javanica* Bth²⁵. My *Afzelia bijuga* seeds are also now confirmed as such by them, which I had anticipated.

D.javanica is not mentioned by Guppy in any of his works, being probably under the 3 or 4 "*Mucuna* spp." mentioned from Keeling in his paper.

I remain

Yrs sincerely
John Muir

Did I send Dr Lloyd Praeger a copy of my paper (*Bot. Survey of S.Afr.*) "Veget of Riversdale"? He is well known by reputation in S.Africa

Copies of Muir's earlier papers on drift and his "Vegetation of Riversdale" are preserved in Glasnevin; the copies are signed by Muir. In the archives at Glasnevin there is a rough, incomplete draft of a reply to the above letter. This draft is dated October 7 1930, but there is no letter with this date in the archives at the University of Stellenbosch. It must be assumed that Miss Knowles did not send the letter, and that Muir's next letter reminded her about replying.

Riversdale, 19 Nov. 1930

Dear Miss Knowles

I send you the little book²⁶ under separate cover, also in this letter a few seeds of *Ipomoea pes caprae* (= *I biloba*) from the beach drift of Pondoland (Urnzinivuba River at St. John's). The bare ones are the typical: the others are fresh.

I do not know what to do about the paper of Guppy's. It is the first of those mentioned under his name in *Plants Seeds & Currents* p.vii (Dispersal . . . Keeling Island). The year was probably 1890. I have seen the 1889 number but although there was some thing about Keeling Island by him in it it did not deal with the drift at all.

The Vict. Instit. is more a religious society, and I cannot get a copy of the paper in any scientific library.

Would the incumbent of St Patricks Cathedral [Dublin] not have it in their library?

With kind regards, & hoping the seeds will escape the Post Office stamp.

Yours sincerely
John Muir

Dublin, Decr 9 1930

Dear Dr Muir

Your letter with the nice little batch of seeds of *Ipomoea pes Caprae* and your fine paper on "The Vegetation of the Riversdale Area" all arrived this morning. Thank you very much indeed for them I am looking forward to reading your paper with much interest.

I was just about to write to you when your letter came to tell you that through Dr Praeger² I was able to get a short loan of Guppy's paper on the "Dispersal of Plants as Ill. by the Flora of Keeling or Cocos Islands" and made a few extracts for you just to let you know roughly the contents of it. These are so rough I am almost ashamed to send them as I have not had time to type them out; but they will let you see the plan of the paper. I was talking to Dr Praeger about how to have an abstract made for you, but he is of opinion that no abstract is really reliable & that it would be much more satisfactory for you to see the original paper and he said that he was quite sure if you know any member of the Linnean Society that he could borrow it for you. Dr Praeger says the Linnean Society constantly lends books to specialists who are living abroad who have not a good library near. I do hope you will be able to get the paper as it is very annoying not to be able to see the whole literature on the subject one is studying. I am so sorry I have been able to do so little to help you in this matter.

With kind regards and very good wishes for Christmas & the New Year

I am yours sincerely
Matilda C Knowles

Riversdale, 30 XII 1930

Dear Miss Knowles,

Many Thanks for the great trouble you have taken in making a precis of Guppy's article. I have ordered the book itself from Edinburgh as they once sent me the previous vol of the series. Guppy's own reference to his paper gives the wrong year! Schimper gives it as "about 1890". Thus I cd never tell them exactly what I wanted.

I am (notwithstanding the above address) in my summer abode on the Indian Ocean at Still Bay, 25 m from Riversdale. I will send you some fruits and seeds when I return home about Jany. 24th.

In May I hope to go to Lourenzo Marques. Did I send you seeds of *Ipomoea (Calonyction) Bona Nox*, which float well but are said by Guppy to be "variable"? I think I did.²⁸

Would you care for the seedlings of the mangroves (*Rhizoph. mucronata* and *Bruguiera gymn.*²⁹) for the museum sheets or for the students?

Entada scandens and *Caesalpinia Bonducella* I will see in any quantity growing. I have any quantity of seeds from the drift as well.

I have lately settled the problem for S.Afr. of *Aleurites*, *Sophora tomentosa* and *Erythrina indica*.

I have had a bad set back with French red tape which will amuse you. The Director of Agric. Mauritius (who died in Nov.) sent some of my seeds to the Chief of Agric. Madagascar. Both are or were Frenchmen. The Postal authorities of Madagascar wd not allow the entry of my seeds as they are contrary to regulations (fear of diseases &c). and returned them to Mauritius. The Chief of Agric Madagascar was quite willing to examine them but cd. not get them through the customs.

My seeds all belong to Ewarts macrobiotic group and may have been 5 to 100 years old for all anyone knows.

The Madagascar man is the only authority living who cd. name the seeds some of which I gave or lent you. How to manage I do not know, but neither Guppy nor Schimper ever got their *Mucuna* spp. named as the genus is very difficult to determine from seeds.

Otherwise my work is finished.

The Gvt. has ordered seeds for me from Zanzibar, Ceylon, Singapore and Buitenzorg, but the Miss Knowles' of this world are few and far between, and it is rare to find governments or people who will do as much for you, as you would do for them.

With very best wishes

I remain yrs very sincerely
John Muir.

Riversdale, 10.2.1931

Dear Miss Knowles,

I am sending you herewith the following from Portuguese East Africa, although they are I am sure (being also W. Indian) all represented in your noble collection; but of interest maybe because of their new locality:³⁰

6 fresh seeds of *Entada scandens* taken from the shrub

5 segments of the hugh pod of the same which is over 3 ft long. If you glue them together on a flat stick they make a nice specimen. There are often 11-13 segs.

Seeds of *Caesalpinia Bonducella*

Pod of *Caesalpinia Bonducella*

2 fruits of *Anacardium occidentale* L. (Cashew Nut) This had poor powers of flotation, but is discussed by Guppy.

With Kind regards

I remain Yours sincerely
John Muir

I have put in a pod of *Canavalia obtusifolia*. These fresh materials are instructive when placed as controls against drift stuff. Of the latter I have abundance—about 600 seeds of all kinds. Is there anything you would like?

I wish I were back at the Coombe [in Dublin], walking through the dirty streets, with the Irish women all shouting "Good Luck"! I will never forget Dublin, hence also these seeds. Now I am too old alas!

Dublin March 9 1931

Dear Dr Muir

Thank you very much indeed both on my account and on behalf of the Museum for the very nice box of seeds that arrived safely a few days ago. Especially for the pod of *Caesalpinia Bonducella* (of which we had no sample) and also for the pod of *Canavalia obtusifolia*.

It is an excellent suggestion of yours to mount the fresh seeds and place them as controls against the Drift Seeds and I am carrying it out. Our collection will soon be a "noble" one indeed thanks to the many additions you have so kindly sent us.

We are also very pleased with the sections of the *Entada* pod you have given us. We already had a number of sections of a slightly parger pod, but I think yours is really better for exhibition purposes as our show cases are not very large so I am mounting them in the way you describe.

Dublin sends you greetings! At present it is in a whirl of excitement, which I am not very sure is good for it, about the Hospital Sweep Stake³¹. I hope your old friend the Coombe may benefit. With Kindest regards and wishing you the best of good luck

I am
yours sincerely
Matilda C. Knowles

I hope you succeeded in getting Guppys paper?

Riversdale 20.4.1931

Dear Miss Knowles,

I am sending your hypocotyls of two Eastern Mangroves, which you may not have, see Guppy *Nat. Pac.* II.

They will look well glued on cartridge paper some with fruits attached others separate:

[here there is a pen sketch to illustrate the mounting technique suggested]

You will find *Ceriops* illustrated in Schimper's "*Indo-malayische Strandflora*"

The *Rhizophora* in the Western Mangrove is a different species *R. mangle* (Guppy P.S.C.)

I am going up I hope to Portuguese E. Afr. in June, when there is no malaria to have a hunt round and see what I can get lying on the tropic beaches.

I have not succeeded in getting Guppy's Keeling Is paper yet, but I am doing my best to get the volume. I got the old Volume of the Journ. of the Linnean Society with Baron's Madagascar paper from Prof. Thoday of Bangor as a present last week.

Guppy published his papers in a religious transactions, which is perhaps the reason why botanists do not have them! Anyhow they are almost unobtainable today I tried more than a year to get Schimpers "*Indo-mal Strandflora*" and at last got it in Leipzig through the intermediations of a Hollander.

The papers issued by the Buitenzorg Gardens in French & German are hard to get: I mean the Krakatoa ones.

With kind regards, I remain
Yours sincerely
John Muir

Dublin 16 Decr. 1931

Dear Dr Muir

I must apologise for not having sent you a line or two sooner to thank you for all the interesting matter about Drift seeds that I have received from you in the last few months. You are most kind & we are very grateful to you. I have received "The Romance of a Floating Seed"³² most interesting reading. How pleased you and Mrs Muir must have been to run your bean to earth, and what an ingenious plan you adopted to locate it. I congratulate you on your thoroughly satisfactory piece of Research & I am glad to know that *Mucuna quadrilata* is the same as *Mucuna gigantea*. The crocodiles and the hippopotami were interesting side shows that I could have done without. You speak feelingly of the suffering of those who have the misfortune to get the hairs of the pod into their clothes. No wonder the natives call them "i-mamba". I must have some extracts made from your account for my Drift seed case.

With very many thanks and the best of good wishes for 1932 from
Matilda C Knowles

For over a year, there was no correspondence between Muir and Miss Knowles. We may presume that he had exhausted the usefulness of the very small collection of seeds in Dublin, and, as he himself had said, his work was "finished".

Muir's next letter to Dublin enclosed a copy of his paper on drift seeds (Muir, 1932), which was the result of his research, and was probably the reason for stating that his work had finished. Muir did not end his work at that point, however, as he published further articles including his most important paper on drift seeds several years later (see Muir, 1934, 1937).

Riversdale 13 Febr. 1933

Dear Miss Knowles

I send herewith a paper containing two plates of seeds.

Have you by any chance a seed of *Pangium edule* (Flacourtaceae) collected by Guppy in the Dutch E. Indies.

If you could let me see one I would send it back by the very first post, together with a fine fruit of *Heritiera littoralis* for your collection

Yours faithfully
John Muir

Dublin March 31 1933

Dear Dr Muir,

Thank you very much for the paper on "The Beach Drift of South Africa" with the two plates of seeds. These will be most useful here and helpful to all those studying Beach Drift.

I am very sorry we have no specimens of *Pangium edule*. in our collections or you should have had the loan of it with much pleasure.

I am resigning my post here on the 1st of June next and going up to Ballycastle in the North of Ireland to live with a sister who has a little house and a nice garden there. I am looking forward to a good rest during the summer.

If I find any interesting Drift seeds on the coast up there I shall let you know.

You have been so generous in giving us drift seeds for our collections and it is a great satisfaction to me to know that there is such a representative set here. Thank you very much for numerous contributions.

With Kind regards
Yours sincerely
Matilda C Knowles.

Three weeks after writing this letter Miss Knowles died, and her sister died three days later (Praeger, 1949).

CONCLUSION

Although he stated that his work was finished in 1930, Muir did not in fact conclude his researches then. From other unpublished letters (from H. N. Ridley to J. Muir, in STE-U) we learn that Muir visited London and Kew at least once. Further, his main publications on drift fruits and seeds were published between 1932 and 1937.

The co-operation indicated by the letters published here, resulted in the assembly in Dublin (DBN) of a small collection of drift seeds and herbarium specimens of coastal plants. Muir acknowledged the help given by the Dublin botanists Dr. Praeger and Miss Knowles in his publications. There is little doubt that Muir greatly valued the help given by Dublin, and the short correspondence probably would have continued for many years had Miss Knowles not died.

ACKNOWLEDGMENTS

I am very grateful to Prof P. G. Jordaan for sending me copies of Miss Knowles letters and for his assistance with the identification of Muir's seeds. My thanks are also due to Dr C. R. Gunn for his help.

NOTES

- 1 DBN mss. H. B. Guppy to C. W. Steele, National Museum, Dublin, 10 May 1915.
- 2 DBN mss. H. B. G. to The Director, National Museum, Dublin, 25 May 1915.

- 3 *Proc. Royal Irish Academy*, 35B: 29–54. 1919.
- 4 correctly *Barringtonia asiatica* (L.) Kurz; see Gunn & Dennis (1976).
- 5 the specimens listed have been examined by Dr C. R. Gunn and identified as follows:
 - 352 and 83—*Intsia bijuga* (Colebr.) O. Kuntze
 - 171 and 40—*Dioclea reflexa* Hook.f.
 - 255 and 373—*Mucuna myriaptera* Baker
 - 36—*Dioclea reflexa*
 - 324—*Dioclea reflexa*
 - 445—*Canavalia* sp. (Muir named this *Canavalia bonariensis* Lindl.)
 - 26, 314 and 443—*Mucuna gigantea* DC.
- 6 correctly *Entada phaseoloides* (L.) Merrill; for discussion of *Entada* spp. see Gunn & Dennis (1976).
- 7 correctly *Caesalpinia bonduc* (L.) Roxb.
- 8 STE-U mss. G. P. Farran to M. C. Knowles, undated (copy only in DBN).
- 9 there are "drift seeds" collected by Guppy at Kew, as well as those already noted in DBN. There are no Guppy specimens in BM.
- 10 in transcribing this rough draft pencil insertions have been placed into the main text in the appropriate place. The section in brackets appears to belong here.
- 11 i.e. Cocos (Keeling) Islands in the Indian Ocean north of Australia.
- 12 Miss Knowles originally wrote "like *Mucuna* but raphe very narrow".
- 13 deleted in rough draft.
- 14 *Observations of a Naturalist in the Pacific between 1896 and 1899; vol. II Plant-Dispersal*. 1906, London.
- 15 Folk-lore of Some South African Sea Beans (Muir, 1929a): a signed copy was sent by Muir to Miss Knowles on 29 July 1930, although Muir dated it "29.7.31" (DBN).
- 16 Schimper A. F. W., *Indo-malayische Strandflora*. 1891, Jena.
- 17 Dispersal of plants as illustrated by the flora of the Keeling or Cocos Islands. *Journ. Trans. Victoria Inst.*, 24: 267–306 (1890).
- 18 Miss Knowles corresponded with Guppy (see Guppy, 1917) but no letters are extant. They never met.
- 19 Tananarive, Madagascar.
- 20 *Scaevola plumieri* Vahl; Muir sent fruits from shrubs with the dried pericarp intact (Riversdale Coast, July 1930) and "stones" from beach drift which had lost their pericarp (Riversdale Coast, July 1930); DBN.
- 21 material was incorporated and is still intact in DBN.
- 22 see 15 *supra*.
- 23 a rough draft of this letter, differing slightly from the copy sent is in DBN.
- 24 this postscript is added to the letter on the top of the first page. It seems that Miss Knowles wrote this letter before she received the letter sent by Muir on 19 August 1930, and that the footnote was in reply to that letter.

- 25 see 5 *supra*.
- 26 Vegetation of the Riversdale Area (Muir, 1929b); copy signed by Muir in DBN.
- 27 Praeger worked in the National Library in Dublin; he was Chief Librarian.
- 28 there are no seeds of this in DBN.
- 29 *Rhizophora mucronulata* Lam., *Bruguiera gymnorrhiza* Lam.
- 30 see 5 *supra*; specimens in DBN.
- 31 a lottery run to provide funds for Dublin hospitals and prize money for horse-racing.
- 32 Muir, 1931b.

REFERENCES

- COLGAN, N., 1919. On the Occurrence of Tropical Drift Seeds on the Irish Atlantic Coasts. *Proc. R. Ir. Acad.* **35B**: 29-54.
- GUNN, C. R. and DENNIS, J. V., 1976. *World Guide to Tropical Drift Seeds and Fruits*. New York: Quadrangle/New York Times Book Co.
- GUPPY, H. B., 1917. *Plants, Seeds and Currents in the West Indies and the Azores*. London: Williams & Norgate.
- HOPKINS, H. C., 1972. John Muir. In: *Dictionary of South African Biography*. Vol. 2; pp. 500-501. Cape Town: Tafelberg-Uitgewers Ltd.
- MUIR, J., 1929a. Folk-lore of South African Sea Beans. *J. med. Ass. S. Afr.* **3**: 1-6.
- MUIR, J., 1929b. Vegetation of the Riversdale Area. *Mem. bot. Surv. S. Afr.* **13**.
- MUIR, J., 1931a. *Alien and Indigenous Fruits and Seeds in the South African Beach Drift*. Riversdale: private publication.
- MUIR, J., 1931b. The Romance of a floating seed (*Mucuna gigantea*). *South-western Echo* (21 November 1931).
- MUIR, J., 1932. The beach drift of South Africa. *J. bot. Soc. S. Afr.* **18**: 5-10.
- MUIR, J., 1934. The correlation of arrival sites of alien seeds with ocean currents. *S. Afr. geogr. J.* **17**: 13-18.
- MUIR, J., 1937. The Seed-Drift of South Africa and some influences of ocean currents on the strand vegetation. *Mem. bot. Surv. S. Afr.* **16**.
- PRAEGER, R. L., 1949. *Some Irish Naturalists*. Dundalk: Tempest.
- VAN BLERK, N., 1972. John Muir. In: *The Standard Encyclopaedia for Southern Africa*, Vol. 7, pp. 633-634. Cape Town: Nasou Ltd.

BOOK REVIEWS

POLLINATION MECHANISMS, REPRODUCTION AND PLANT BREEDING, by R. Frankel and E. Galun with pp. xi+281, 77 figures and 39 tables. Berlin-Heidelberg—New York, Springer-Verlag, 1977. U.S. \$26,40.

Pollination Mechanisms, Reproduction and Plant Breeding is a cloth bound volume and the second in the series "Monographs in Theoretical and Applied Genetics".

The authors set out to "furnish under one cover an integrated botanical, genetical and breeding-methodological treatment of the reproductive biology of spermatophytes—mainly angiosperms." The book is intended for "biology and agricultural students at the graduate level, to plant breeders and other people interested in acquiring a broader knowledge of the reproductive biology of higher plants."

The first of the three chapters deals briefly with the significance of different pollination mechanisms and more extensively with the mode of reproduction in higher plants and the ecology and dynamics of pollination. The second chapter is devoted to self-fertilizing crops. The evolutionary aspects and mechanism of autogamy is discussed, and the chapter is concluded with a very apt description of emasculation and controlled pollination.

The third chapter, which comprises about two-thirds of the text, provides an excellent detailed discussion on sexual reproduction in higher plants, control and modification of sex, incompatibility and male sterility and the utilization of these in plant breeding.

The book is a comprehensive and up to date reference text. Nearly two-thirds of the 948 references are dated 1960 or later. There are few typographical errors and the editing appears to have been careful. The book provides factual information which had not previously been obtainable in one volume. The authors employ a very effective system of headings and subheadings which enable the reader to identify specific topics without delay.

In the South African context this book should be compulsory reading for final year plant breeding undergraduate students, post graduate students, research workers, and university teachers specializing in this field. But priced at U.S. \$26,40 it will most probably only be libraries of research institutes and universities which will acquire copies of this publication.

H. A. VAN NIEKERK

PROCEEDINGS OF THE SECOND NATIONAL WEEDS CONFERENCE OF SOUTH AFRICA, 1977, pp. 344, with 82 figures and tables, thread sewn with paper cover, R15,00 Obtainable from the publisher: A. A. Balkema, P.O. Box 3117, Cape Town.

Conferences come and go and result inevitably in: "the Proceedings of . . .". Organising committees often seek through their choice of papers, to endow their conference proceedings with a larger function and status—that are seldom achieved. The *Proceedings of the Second National Weeds Conference of South Africa* however, has a function and has attained a status that was not really aspired to by the organisers. These proceedings set out to be nothing more than the written record of 26 research contributions relating to a variety of weed problems. But because of a growing realisation of the importance of weeds in South Africa and the dearth of information about them, these proceedings find themselves elevated almost automatically to the status of a "national review" and "prescribed reading" for anyone interested in our weed problems. They must be assessed in this light.

Judged as a "national review" of current weed problems and research, these proceedings succeed in providing a fairly balanced and comprehensive coverage of the country's

weed problems, the plants and conditions that cause them, and of new developments in control and utilisation research. The emphasis is on the very grave threat that invading weed species pose to our rich and beautiful Cape Flora. In view of this emphasis, it is refreshing to also find included a paper championing one plant, black wattle, that is widely regarded as a weed by conservationists.

Other contributions of note, include works on the chemical control of: bush encroachment, Nassella tussock, wild oats; and of the weeds of vineyards, maize, wheat, clover pastures and sugar cane. There are four papers relating to the biological control of *Opuntia aurantiaca* (jointed cactus), and other pest plants. And botanical studies which provide an understanding basic to the control of weeds, have also been included, e.g. a study of the taxonomy of *Lantana*, and one on the growth kinetics of *Eichornia crassipes* (the water hyacinth).

However, the coverage is not complete, and falls short of what one would expect of a national review in that it lacks any indication of empirically evaluated research and control priorities. And, whilst the human population explosion (the most important single factor guaranteeing more and bigger weed problems in the future) figures in several papers, insufficient attention is paid to the likely affect of future land use on weed problems. The publication is also the poorer for having neither an index nor an overall summary.

Whilst these proceedings may fall short of what is required of a "national review" there is no doubt at all that they must be regarded as prescribed reading for weed scientists as well as for farmers, and conservationists who are interested in the weed problems that threaten the environment and productivity of our sub-continent. Together with the proceedings of the First National Weeds Conference of South Africa, 1974 (which is unpublished and now almost unobtainable) they provide the first modern picture of weed problems and weed research accents in South Africa.

With these proceedings, it is now possible to combine and extrapolate the estimates of various authors to derive an estimate of what weeds cost South Africa annually. However dangerous an exercise like this may be, it is important to scientist and layman alike, that it can be indulged in.

In view of their importance, is it too late to appeal for the publication of the proceedings of the First National Weeds Conference to supplement the work reviewed here?

The preparation of the various contributions was supervised by the individual authors, and since printing was by offset litho minor typing errors and inconsistencies in format have been perpetuated. These do not detract from the value of this workmanlike production. But the cover may prove to be a little on the light side for the attention that its contents will receive, and the use that will be made of them.

Dr. D. P. Annecke of the Plant Protection Research Institute (Department of Agricultural Technical Services), chairman of the organising committee, and Messrs. Agricura who made a generous donation towards printing costs, are to be congratulated on this timely publication.

M. J. WELLS

SUPPLEMENT TO AQUATIC PLANTS OF AUSTRALIA, by Helen I. Aston.

Melbourne University Press, 1973 and reprint 1977.

Reviewed: *Jl S. Afr. Bot.* 41 (4): 273 (1975).

An eight page, loose-insert supplement applicable to both the original 1973 printing and the 1977 reprint of *Aquatic Plants of Australia* has been prepared. It contains updated information on Australian aquatic plant taxa, together with a bibliography, and is automatically included with each copy of the reprint. Holders of the 1973 printing may obtain a copy of the supplement free of charge from Melbourne University Press, P.O. Box 278, Carlton South, Victoria, Australia 3053.

Self-addressed envelope (10 inches x 7 inches) MUST accompany application.

THE GENUS *GALIUM* L. (RUBIACEAE) IN SOUTHERN AFRICA

CH. PUFF*

(Institute of Botany, University of Vienna, Austria)

ABSTRACT

A new classification of the genus *Galium* in Southern Africa is proposed, based on morphological investigations, karyology, pollen measurements, and ecological observations. Twenty taxa belonging to fourteen species are recognized: (1) *G. thunbergianum*, with var. *thunbergianum* and var. *hirsutum* in East Rhodesia, Transvaal, Swaziland, Natal, Orange Free State, Lesotho, and Eastern Cape Province; (2) *G. capense*, with ssp. *capense* in the South West Cape and Eastern Cape Province, ssp. *namaquense* (stat. nov.) in the Western Cape Province, and ssp. *garipense* (stat. nov.) with var. *garipense* and var. *wittbergense* (stat. nov.) in Transvaal, Natal, Orange Free State, Lesotho, and Eastern Cape Province; (3) *G. monticolum*, a rare species from the Western Cape Province; (4) *G. bredasdorpense* (sp. nov.) endemic to the limestone formations in the Bredasdorp district; (5) *G. amatymbicum*, a rare species from the Eastern Cape Province; (6) *G. bussei*, with var. *bussei* and var. *glabrum* in Rhodesia; (7) *G. scabrelloides* (sp. nov.) in the South Transvaal, Swaziland, Natal, Orange Free State, Lesotho, and Eastern Cape Province; (8) *G. scabrellum* in East Rhodesia; (9) *G. subvillosum*, with var. *subvillosum* and var. *subglabrum* (var. nov.), (10) *G. mucroniferum*, with var. *mucroniferum* and var. *dregeanum* (stat. nov.), and (11) *G. undulatum* (nom. nov.) in the South West Cape; (12) *G. tomentosum* in the Cape Province and South South West Africa (and Orange Free State); (13) *G. chloroanthum* in East Rhodesia; (14) *G. spurium* ssp. *africanum*, a rare taxon occurring in Transvaal, Natal, and Cape Province.

New chromosome numbers are reported for *G. scabrelloides* and *G. capense* ssp. *garipense* var. *wittbergense* ($n = 11$, $2n = 22$), and *G. mucroniferum* var. *mucroniferum* and *G. subvillosum* var. *subvillosum* and var. *subglabrum* ($n = 22$, $2n = 44$). Previously published chromosome numbers of *G. thunbergianum* var. *thunbergianum* and var. *hirsutum* and *G. capense* ssp. *garipense* var. *garipense* ($n = 11$, $2n = 22$) and *G. tomentosum* ($n = 22$, $2n = 44$) are confirmed by additional new counts.

UITTREKSEL

DIE GENUS *GALIUM* L. (RUBIACEAE) IN SUIDELIKE AFRIKA

'n Nuwe indeling van die genus *Galium* in Suidelike Afrika word voorgestel; dit word baseer op morfologiese ondersoeke, kariologie, stuifmeel afmetings en ekologiese waarnemings. Twintig taksa behorende tot veertien soorte word erken: (1) *G. thunbergianum*, met var. *thunbergianum* en var. *hirsutum* in Oos-Rhodesië, Transvaal, Swaziland, Natal, Oranje-Vrystaat, Lesotho en Oostelike Kaapprovinsie; (2) *G. capense*, met ssp. *capense* in die Suidwestelike Kaap en Oostelike Kaapprovinsie, ssp. *namaquense* (stat. nov.) in die Westelike Kaapprovinsie, en ssp. *garipense* (stat. nov.) met var. *garipense* en var. *wittbergense* (stat. nov.) in Transvaal, Natal, Oranje-Vrystaat, Lesotho en Oostelike Kaapprovinsie; (3) *G. monticolum*, 'n skaars spesies vanaf die Westelike Kaapprovinsie;

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Accepted for publication 1st November, 1977.

(4) *G. bredasdorpense* (sp. nov.) endemies aan die kalkbulte in die Bredasdorp-distrik; (5) *G. amatymbicum*, 'n skaars spesies van die Oostelike Kaapprovinsie; (6) *G. bussei*, met var. *bussei* en var. *glabrum* in Rhodesië; (7) *G. scabrelloides* (sp. nov.) in Suid-Transvaal, Swaziland, Natal, Oranje-Vrystaat, Lesotho en Oostelike Kaapprovinsie; (8) *G. scabrellum* in Oos-Rhodesië; (9) *G. subvillosum* met var. *subvillosum* en var. *subglabrum* (var. nov.), (10) *G. mucroniferum*, met var. *mucroniferum* en var. *dregeanum* (stat. nov.) en (11) *G. undulatum* (nom. nov.) in die Suidwestelike Kaap; (12) *G. tomentosum* in die Kaapprovinsie en suid Suidwes-Afrika (en Oranje-Vrystaat); (13) *G. chloroionanthum* in Oos-Rhodesië; (14) *G. spurium* ssp. *africanum*, 'n skaars takson wat voorkom in die Transvaal, Natal en Kaapprovinsie.

Nuwe chromosoomgetalle word gegee vir *G. scabrelloides* en *G. capense* ssp. *garipense* var. *wittbergense* ($n = 11$, $2n = 22$), en *G. mucroniferum* var. *mucroniferum* en *G. subvillosum* var. *subvillosum* en var. *subglabrum* ($n = 22$, $2n = 44$). Voorheen gepubliseerde chromosoomgetalle in *G. thunbergianum* var. *thunbergianum* en var. *hirsutum* en *G. capense* ssp. *garipense* var. *garipense* ($n = 11$, $2n = 22$) en *G. tomentosum* ($n = 22$, $2n = 44$) word bevestig deur aanvullende nuwe tellings.

INTRODUCTION

The Southern African members of the genus *Galium* are badly in need of revision, the last comprehensive treatment of the genus being that of Sonder (1865) who, in *Flora Capensis*, listed 18 taxa belonging to 14 species, 6 of which were newly described by him. Since then only two short articles dealing with South African taxa of the genus have been published (Phillips, 1917: description of a new variety; Salter, 1937: discovery of dioecism in *G. tomentosum*). A few more publications which primarily concern tropical East African species only marginally touch problems encountered in South African taxa: Brenan (1953) describes three new varieties of *G. bussei* and discusses their confusion with *G. stenophyllum*; Ehrendorfer & Verdcourt (1973) discuss the relationships between various tropical species, some of which extend into South Africa; Verdcourt (1975) discusses the identity of *G. spurium* ssp. *africanum* (= '*G. aparine*') and separates *G. thunbergianum* into two varieties.

The present publication not only covers South Africa (including Transkei), South West Africa, Swaziland and Lesotho, but also Rhodesia,¹ where a number of taxa centred in the tropics reach their southern limit of distribution. In order to demonstrate the often obvious links between a number of tropical and Southern African species this addition was considered necessary and useful.

The present paper offers a revision of the nomenclature and taxonomy of the taxa in question, but also includes detailed information about morphology, karyology, pollen measurements, as well as distribution, habitats and flowering periods of the majority of taxa, although it needs to be stressed that this study must by no means be considered complete, since information available for some of the species still remains rather unsatisfactory.

¹ No collections seem to exist from Botswana and Moçambique (South of the Zambezi), although particularly in the latter country some taxa are likely to occur in the mountain ranges bordering Rhodesia.

MATERIAL AND METHODS

The present investigations were based on herbarium material borrowed from the herbaria B, BOL, E, GOET, GRA, K, LISC, NBG, NH, NU, P, PRE, S, SAM, SRGH, UPS, W, WIND, and WU (abbreviations after *Index Herbariorum*, Holmgren & Keuken, 1974), and my personal collections made while in Southern Africa between March 1976 and February 1977. Some of the material was cultivated in a garden in Pietermaritzburg/Natal.

Karyological Investigations and Pollen Measurements

Material and methods as described in Puff (1976a).

Sem Investigations

Living or herbarium material was viewed with a Hitachi SSM 2 at an accelerating voltage of 20 kV. Living material usually needed no preparation at all (Figs 6c, 8e, 8d, for example), although sometimes results were only satisfactory if it was first critical point dried and then coated with gold-palladium (Figs 8a, 8b, for example). Herbarium material generally only required coating with gold-palladium. Flowers taken from herbarium sheets were first boiled to restore their original shape, then subjected to critical point drying, and finally gold-palladium coated (Fig. 8c); this method cannot always be used because of unnatural deformations as a result of this treatment.

Distribution Data and Maps

The "Degree Reference System" as outlined by Edwards & Leistner (1971) is adopted. For greater accuracy, quarter-degree references are given whenever possible. In the distribution maps one dot stands for all collections made in a single quarter-degree square, whereby the actual position of any one collection within the square is neglected. Degree references are also used for collections from Rhodesia.

To establish Degree Reference Numbers the index of *Southern African Place Names* (Leistner & Morris, 1976) was consulted. In the listings of collections the spelling of place names has also been adjusted to that given in Leistner & Morris. Place names used by earlier workers which, in the meantime, have changed, are usually given in brackets after their modern equivalent (synonymy after *Zoo-Historical Gazetteer*, Skead, 1973). To trace down exact localities of Ecklon & Zeyher collections, *Standörter-Verzeichnis* (including *Nachtrag*) and *Vergleichungen* (Drège, 1847a, 1847b, 1848) were consulted.

Distribution maps of taxa centred in tropical (East) Africa (Figs 12, 16, 18, 22): The extra-Southern African range of distribution of these taxa was compiled from data given in *Enumeratio Plantarum Aethiopiae Spermatophyta* (Cufodontis,

1965) and *Flora of Tropical East Africa: Rubiaceae I* (Verdcourt, 1976), and from herbarium material I have seen myself.

Altitudes given in feet were always converted to metres.

Descriptions

It should be noted that descriptions of taxa also occurring in tropical Africa were drawn up from Southern African material only.

Stem diameters were measured in the mid-stem region unless stated otherwise. In the measurements of leaf widths the reflexed margins were not taken into account.

KARYOLOGY

Chromosome counts were determined from preparations of root tips, somatic mitoses in young buds (walls of ovaries, filaments), pollen mitoses, and pollen mother cell (PMC) meiosis. Since the somatic chromosomes of *Galium* are rather small (and therefore often difficult to count), an attempt was made to determine chromosome numbers from clearly arranged metaphase I and II chromosomes of PMCs whenever possible.

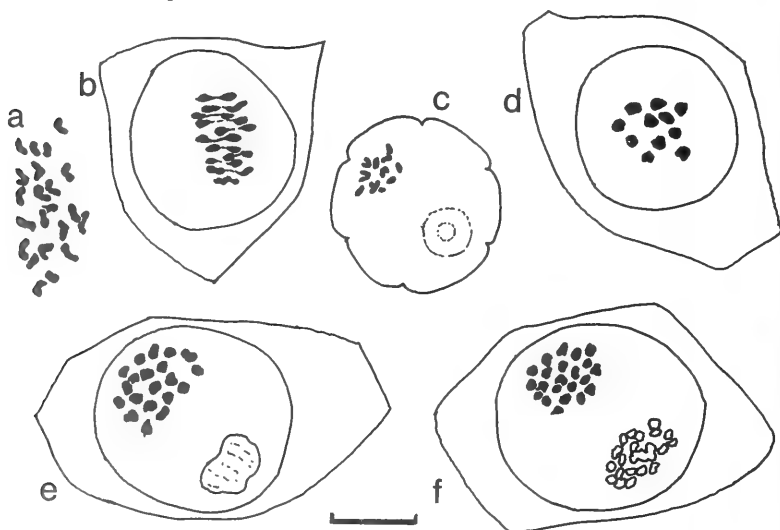


FIG. 1.

Somatic chromosomes of (a) *G. thunbergianum* ($x = 11$; $2n = 22$); pollen mitosis II of (c) *G. capense* ssp. *garipense* ($x = n = 11$); pollen mother cells of various diploid and tetraploid *Galium* taxa (b, d-f): meta-/anaphase I of (b) *G. thunbergianum* ($x = n = 11$), metaphase I of (d) *G. scabrelloides* ($x = n = 11$), metaphase II of (e) *G. spurium* ssp. *africanum* ($x = 10$; $n = 20$) and (f) *G. tomentosum* ($x = 11$; $n = 22$). The bar represents 10 μm (b-f; for a the bar is 5 μm). Further explanations in the text.

All taxa investigated (with the exception of *G. spurium* ssp. *africanum*) have a chromosome base number of $x = 11$, the most common base number in the genus. The tetraploid *G. spurium* ssp. *africanum* is characterized by the derived base number of $x = 10$. Within the $x = 11$ group diploids (*G. thunbergianum*, *G. capense* ssp. *garipense*, *G. scabrelloides*) and tetraploids (*G. subvillosum*, *G. mucroniferum*, *G. tomentosum*) were detected. Chromosome determinations for *G. thunbergianum* var. *thunbergianum* and var. *hirsutum*, *G. capense* ssp. *garipense* var. *garipense*, and *G. tomentosum* (Puff, 1977) are confirmed by additional counts, the chromosome counts for *G. subvillosum* var. *subvillosum* and var. *subglabrum*, *G. mucroniferum* var. *mucroniferum*, *G. capense* ssp. *garipense* var. *wittbergense*, and *G. scabrelloides* are new:

Voucher Specimens for Chromosome Counts

	n	2n	number of individuals investigated
<i>G. thunbergianum</i> var. <i>thunbergianum</i>			
Puff 761221-2/1 (WU) ¹	11		3
Puff 760314-4/2 (WU)	11	22	2
Puff 761125-3/5 (WU)	11		3
Additional counts are published in Puff (1977)			
<i>G. thunbergianum</i> var. <i>hirsutum</i>			
Puff 770102-2/1 (NU, WU)	11	22	6
Puff 761209-7/12 (WU)	11		4
Puff 760314-1/1 (WU)		22	2
Puff 760418-1/4 (NU, WU)	11		3
Puff 761219-5/1 (WU) (Fig. 1a, b)	11	22	4
Additional counts are published in Puff (1977)			
<i>G. capense</i> ssp. <i>garipense</i> var. <i>garipense</i>			
Puff 761220-2/3 (NU, WU)	11		3
Puff 761220-3/1 (WU)	11	22	3
Puff 761226-1/1 (WU)	11		1
Additional counts are published in Puff (1977)			
<i>G. capense</i> ssp. <i>garipense</i> var. <i>wittbergense</i>			
Puff 761218-1/3b (NU, WU)	11	22	5
Puff 761219-1/2 (NU, WU)	11		3
Puff 761219-2/1c,d (WU)	11	22	4
Puff 761219-6/1 (WU)	11		2
Puff 761220-4/1 (WU)	11		3
Puff 761225-2/2 (WU) (Fig. 1c)	11	22	5
Puff 761227-1/1 (NU, WU)	11		4
<i>G. scabrelloides</i>			
Puff 760314-1/2 (WU)		22	2
-2/2 (WU)		c.22	1
-3/1 (NU, WU)	11	22	5
-4/1 (NU, WU)	11	22	4
-8/4 (WU)		22	1

¹ Localities of voucher specimens collected by the author can be found in the "Collections" section of the respective taxa.

	n	2n	number of individuals investigated
<i>Puff</i> 760509-1/1 to -1/5 (all WU)		22	8
<i>Puff</i> 760516-2/5 (WU)		22	2
<i>Puff</i> 761121-3/3 (WU)	11	22	3
<i>Puff</i> 761125-3/6 (WU)	11		2
<i>Puff</i> 761209-7/5 (NU, WU)	11	22	2
<i>Puff</i> 761219-4/1 (NU, WU)	11	22	3
<i>Puff</i> 761220-2/8 (WU)		22	1
-4/1 (NU, WU)	11	22	5
<i>Puff</i> 761221-1/1 (NU, WU)	11		2
-3/1 (NU, WU)	11		3
-4/1 (NU, WU)	11		2
<i>Puff</i> 761225-1/2 (NU, WU)	11		1
<i>Puff</i> 761226-1/2 (WU)	11	22	2
<i>Puff</i> 770101-3/3 (WU) (Fig. 1d)	11		3
<i>G. subvillosum</i> var. <i>subvillosum</i>			
<i>Puff</i> 760908-6/2 (NU, WU)	22		4
<i>Puff</i> 760918-2/1 (NU, WU)	22	44	5
<i>G. subvillosum</i> var. <i>subglabrum</i>			
<i>Puff</i> 760908-5/11 (NU, WU)	22	44	3
<i>Puff</i> 760920-3/1 (NU, WU)	22		4
<i>Puff</i> 760920-2/4 (NU, WU)	22	44	3
<i>G. mucroniferum</i> var. <i>mucroniferum</i>			
<i>Puff</i> 760908-6/3 (WU)	22	44	3
<i>G. tomentosum</i>			
<i>Puff</i> 760910-2/1 (NU, WU) ♀		c.44	2
<i>Puff</i> 760913-1/1 (NU, WU) ♂ (Fig. 1f)	22		3
-1/5 (NU, WU) ♂, ♀	22	44	5
-2/12 (NU, WU) ♂	22		2
<i>Puff</i> 760921-1/1 (NU, WU) ♂	22		4
<i>Puff</i> 760924-2/1 (NU, WU) ♂, ♀	22	44	4
Fagerlind (1937), material of unknown origin (as " <i>G. asperum</i> Thunb.")		44	
Additional counts are published in <i>Puff</i> (1977)			
<i>G. spurium</i> ssp. <i>africanum</i>	20	40	
Counts of material from the Southern Transvaal and Natal are published in <i>Puff</i> (1977). Fig. 1e is from <i>Puff</i> 770102-3/1 (NU, WU).			

POLLEN MEASUREMENTS

Pollen investigations were carried out on 305 individuals belonging to 12 taxa; chromosome numbers of 113 of these were known. The pollen quality, although more or less variable, in general is fairly good (most of the grains well developed and three-nucleate; few grains dead, "giants" or "dwarfs"). Only in *G. scabrelloides*, *G. tomentosum* and *G. spurium* ssp. *africanum* were abnormal grains found

more frequently. The occurrence of abnormal grains in these taxa, however, seems to vary even within the population level (particularly in *G. tomentosum*).

It is obvious from Figs 2 and 3 that the average pollen diameters of diploids are smaller than these of tetraploids. Within the diploids, the pollen of *G. thunbergianum* is, on the average, smaller than that of the other taxa. Taking into account the fact that within a given ploidy level pollen diameters are \pm constant in closely related taxa (cf. Puff, 1976a and literature cited there), it can be concluded that *G. capense* ssp. *capense* and ssp. *namaquense* (no chromosome numbers known) are diploid, like *G. capense* ssp. *garipense*.

In tetraploids, pollen sizes of a particular species seem to have a much larger range than those of diploid species (for example, *G. spurium* ssp. *africanum*: 22.4 μ m to 26.5 μ m—a range of 4.1 μ m). *G. subvillosum*, the closely related *G. mucroniferum*, and the presumably polyploid (tetraploid?) *G. undulatum* have much larger grains than the other tetraploids.

The pollen grains of the tetraploid *G. spurium* ssp. *africanum* (Fig. 3c) are, on the average, larger than those of the North hemispheric *G. spurium* f. *spurium* and f. *vaillantii* (DC.) R. J. Moore (diploid, $n = 10$; 18–24 μ m: Moore, 1975): this once again seems to prove that in related taxa pollen becomes larger with increasing ploidy level. The average pollen diameters of *G. spurium* ssp. *africanum*, however, are smaller than those of the hexaploid and (at least morphologically) closely allied *G. aparine* f. *aparine* and f. *intermedium* (Bonnet) R. J. Moore ($n = 33$; 25–31 μ m: Moore, 1975).

Pollen measurements of plants belonging to the “*G. aparine-spurium* complex” would indicate the occurrence of (at least some) diploids: for a discussion of this problem refer to *G. spurium* ssp. *africanum* “Critical Remarks”.

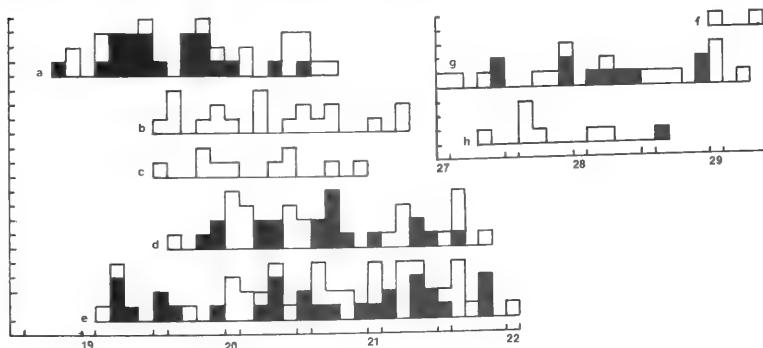


FIG. 2.

Average pollen diameters in μ m of *G. thunbergianum* (a); *G. capense* ssp. *capense* (b), ssp. *namaquense* (c), and ssp. *garipense* (d); *G. scabrelloides* (e); *G. undulatum* (f); *G. subvillosum* (g); *G. mucroniferum* (h). Individuals investigated karyologically: black.

Vertical scale is numbers of individuals.

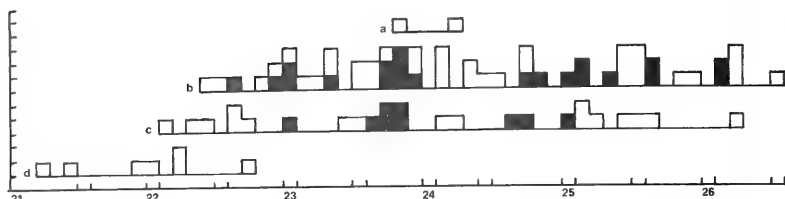


FIG. 3.

Average pollen diameters in μm of *G. chloroionanthum* (a); *G. tomentosum* (b); *G. spurium* ssp. *africanum* (c); "*G. spurium-aparine* complex" (d). Individuals investigated karyologically: black. Vertical scale is numbers of individuals.

It should also be noted that, in addition to the correlation between pollen diameter and ploidy level, there also seems to be a size correlation between pollen mother cells and chromosomes: As can be seen in Fig. 1, pollen mother cells of tetraploids tend to be somewhat larger than those of diploids (compare Fig. 1e, f and b, d), while, on the contrary, chromosome size somewhat decreases with increasing ploidy level (particularly obvious in Figs 1d and f). This phenomenon has already been observed in closely allied species complexes (Puff, 1976b and literature cited there) but, as can be seen here, it also seems to hold true for unrelated or at least not closely related taxa of a genus.

MORPHOLOGY

Habit, stem and branching

With the exception of *G. spurium* ssp. *africanum* (annual) all Southern African taxa are perennials with an often more or less woody base or rootstock/rhizome. In *G. tomentosum* the lower half of the stem is often very woody (up to 20 mm in diam. near the base), but this is never so pronounced in the other species. The length of the stems ranges from 2,5(3) m (*G. tomentosum*) to ca. 100 mm (*G. thunbergianum*, for example), their diameters (in the mid-stem region) from ca. 3(4) mm (*G. tomentosum*) to less than 1 mm (*G. amatymbicum*). Stems are sometimes more or less terete near the base (*G. capense*, for example), but always 4-angled (collenchyma strands) upwards. Stems may be erect or ascending (*G. capense* ssp. *garipense*, for example), caespitose (*G. amatymbicum*) or scrambling or straggling over surrounding vegetation (*G. tomentosum*, for example). They are usually green, but sometimes purplish or purple (anthocyanin. *G. subvillosum*, for example). Internode lengths vary from 80–100 mm (*G. chloroionanthum*, *G. tomentosum*, for example) to ca. 1–5(6) mm (*G. bredasdorpense*).

The branching is often very variable (sometimes even within a single species) and is probably—as demonstrated for the non-South African *Galium* sect. *Aparinoides* (Puff, 1975)—influenced by environmental factors. Depending on the angle between main axis and lateral branches and the length of the latter, the shape of the plants is broadly pyramidal (long, more or less horizontal lateral branches

which decrease in length towards the apex; *G. scabrelloides*, for example), narrowly pyramidal (acute angle between axis and short lateral branches; *G. monticolum*, for example) or (narrowly) cylindrical (short, more or less horizontal lateral branches of approximately equal length; *G. mucroniferum*, for example).

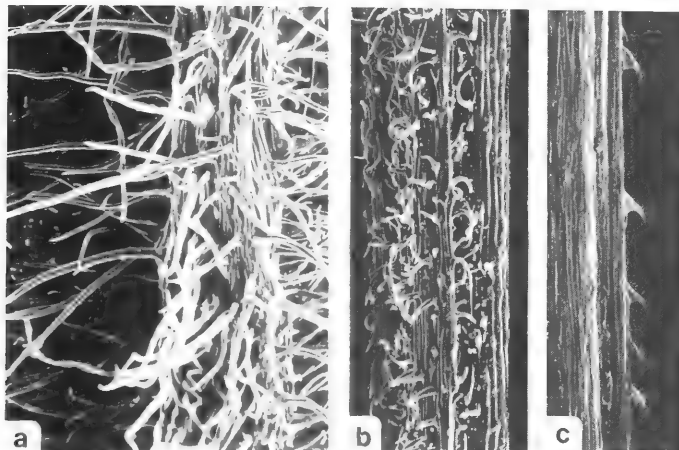


FIG. 4.

Stem portions of *G. tomentosum* (a), *G. capense* ssp. *capense* (b), and *G. spurium* ssp. *africanum* (c) showing characteristic hair covering, a, c: $\times 20$; b: $\times 30$.

The indumentum of the stems can consist of densely set long, more or less spreading whitish hairs (villous; *G. tomentosum*: Fig. 4a), short, spreading white hairs (*G. subvillosum*, for example), short, curled white hairs (*G. capense*: Fig. 4b), more or less massive reversed prickles on the collenchyma strands (*G. spurium* ssp. *africanum*: Fig. 4c, for example), or minute prickles (*G. capense* ssp. *garipense* var. *garipense*, for example). In some taxa the stems are glabrous.

Leaves

Leaves and leaf-like stipules are arranged in whorls of 4 (*G. thunbergianum*), 6 (*G. undulatum*, for example), 6–8 (*G. capense* ssp. *namaquense*, for example), or 6–10 (*G. bussei*, for example). They vary greatly in shape and length: middle cauline leaves can be roundish-ovate, obovate, oblanceolate, ovate-lanceolate, linear-lanceolate or linear, and are ca. 2 mm (*G. bredasdorpense*) up to 35(40) mm (*G. chloroionanthum*) long. Leaf shape and size can be quite variable within a species (cf. *G. tomentosum* and *G. thunbergianum*: Fig. 5a, b), and even a population (cf. Fig. 5a) most probably due to environmental influences [as in the Central European *G. mollugo* group (Zimmermann, 1932) and *Galium* sect. *Aparinoides* (Puff, 1975)]. In the majority of taxa, however, at least the leaf

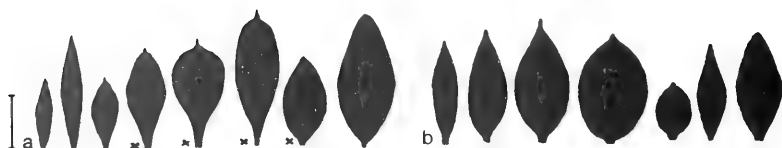


FIG. 5.

Variation in size and shape of middle cauline leaves of *G. tomentosum* (a; "x" denotes leaves taken from one population), and *G. thunbergianum* (b). The bar represents 10 mm.

shape remains more or less constant. The leaves of all taxa are 1-nerved with the exception of those of *G. thunbergianum* (3-nerved). In all South African taxa the apex of the leaf has a more or less distinct hyaline point or mucro (cf. *G. scabrelloides*, Fig. 6c). The leaf margins are often strongly revolute (cf. *G. capense* ssp. *namaquense*: Fig. 6b). Leaf texture ranges from more or less membranaceous (*G. amatymbicum*) to more or less coriaceous (*G. tomentosum*, for example).

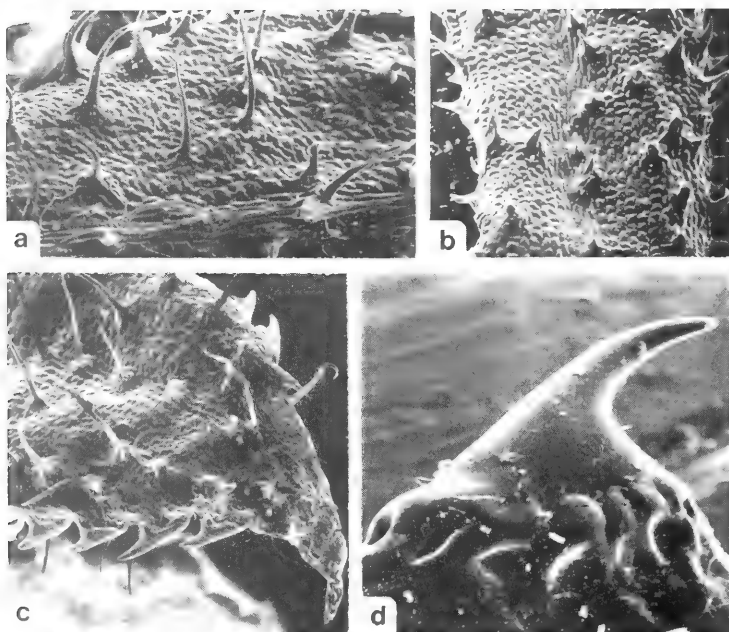


FIG. 6.

Leaf portions of *G. subvillosum* var. *subvillosum* (a), *G. capense* ssp. *namaquense* (b), and *G. scabrelloides* (c, d) showing characteristic hair covering. a-c: $\times 20$; d: $\times 120$.

The following types of indumentum occur: (coarse) reversed prickles on the margin (*G. scabrelloides*: Fig. 6c, *G. tomentosum*: Fig. 6d) and/or white, \pm straight spreading hairs on the lamina (*G. subvillosum*: Fig. 6a, *G. scabrelloides*: Fig. 6c, for example), or small, \pm forwardly directed prickles on margin and lamina (*G. capense* ssp. *namaquense*: Fig. 6b). In some taxa (*G. thunbergianum* var. *thunbergianum*, for example) the leaves are always glabrous.

Synflorescences

In *Galium* the whole inflorescence system is a monotelic synflorescence sensu Troll (1964): main axes and all other branches (axes) terminate in a flower. To avoid too complex descriptions of the synflorescences all lateral "inflorescences" arising from the main axis are here called paracladia (cf. Fig. 7: pc).

Fig. 7 represents the full spectrum of synflorescence types found in Southern African *Galium* species: Fig. 7a depicts the most common type (in *G. capense*, *G. scabrelloides*, *G. tomentosum* and others), in which the paracladia are many-

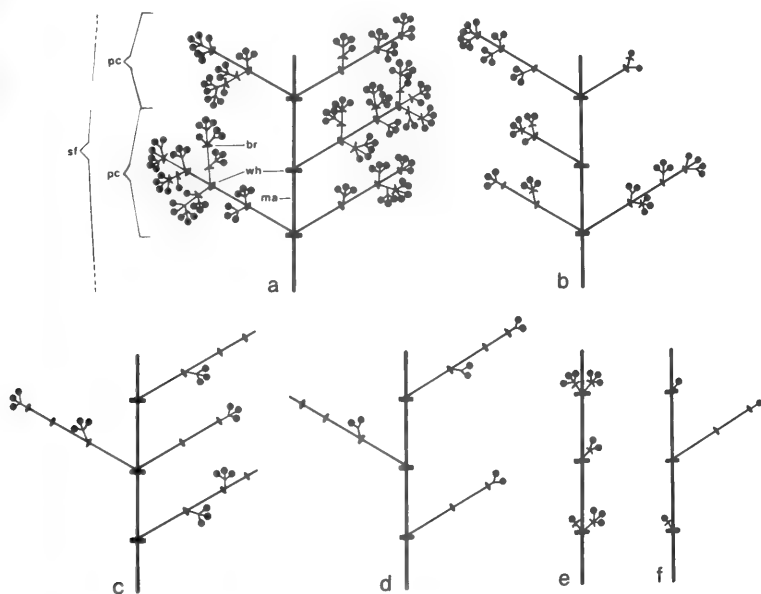


FIG. 7.

Schematic illustration of synflorescence types. Only three nodes of the synflorescence region are shown; it is taken into account that not always two, but often only one paracladium (pc), depending on the species, is produced at one node. br: bract(s) or whorl of bracts; ma: main axis; sf: synflorescence; wh: whorl of foliage leaves. Further explanations in the text.

flowered and the flowers are located on axes of up to the fourth order (in taxonomic literature frequently somewhat incorrectly termed "axillary panicles"). The type illustrated in Fig. 7b (in *G. thunbergianum*, *G. undulatum*, for example) has somewhat fewer-flowered paracladia with flowers only on axes of the second and third order. Types transitional between those of Fig. 7a and b may occur (owing to environmentally controlled reduction in flower number?), and are fairly common particularly in *G. capense*. The types illustrated in Fig. 7c and d have paracladia further reduced: they consist of only one of two axillary or terminal groups of three or two flowers (*G. subvillosum* and *G. mucroniferum*, respectively). In the type illustrated in Fig. 7e the paracladia are very short and have a whorl of leaf-like bracts and three to one flowers only (*G. bredasdorpense*). Finally, Fig. 7f shows a type in which the paracladia are reduced to the terminal flower: in *G. spurium* ssp. *africanum* and *G. chloroionanthum* the one-flowered paracladia are always short (in the latter there is always a bract just below the flower), while in *G. amatymbicum* the single flowers may also be located on more or less long paracladia.

It should be noted that the above reduction series in the synflorescence region does not reflect direct phylogenetic relationships of the taxa mentioned as examples. Such reduction series have evolved independently from each other in several other *Galium* species.

The shape of the synflorescence may vary considerably depending on the length of the paracladia and the angle between paracladia and the main axis: cf. "Habit, Stem and Branching".

Pedicle length can range from (0,5)1(2) mm (*G. amatymbicum*, for example) to 10(20) mm (*G. mucroniferum*, for example); in ♀ plants of *G. tomentosum* they are much elongated and up to 60(90) mm long. They may be more or less thick and firm (*G. spurium* ssp. *africanum*, for example) or thin, more or less filiform (*G. amatymbicum*), straight and more or less divaricate (most taxa) or more or less arcuate (*G. spurium* ssp. *africanum*, for example) in fruit. In the majority of taxa they are glabrous; in *G. spurium* ssp. *africanum* they are often beset with reversed prickles, in *G. subvillosum* var. *subvillosum*, for example, with more or less long, whitish hairs; in *G. tomentosum* they are villous.

The peduncles are usually about as long as the pedicels and correspondingly hairy.

Flowers

All Southern African taxa with the exception of the dioecious *G. tomentosum* (Fig. 8a, b: ♀, note rudimentary stamina; Fig. 8c: ♂) have hermaphrodite flowers. The 4-merous corolla is always rotate, glabrous (most taxa) or somewhat hairy outside (*G. scabrelloides*, cf. Fig. 8d, or *G. thunbergianum* var. *hirsutum*, for example). The corolla lobes are more or less ovate to triangular, about as long as wide (*G. chloroionanthum*) or (much) longer than wide (all other taxa), acute or

acuminate, but never obtuse. Corolla colour ranges from brilliant yellow, yellow, pale and creamy yellow, yellowish-green to greenish-white or whitish (sometimes colour is variable even within a species: *G. thunbergianum*, for example), but none of the Southern African taxa have pure white corollas. In *G. subvillosum*, the

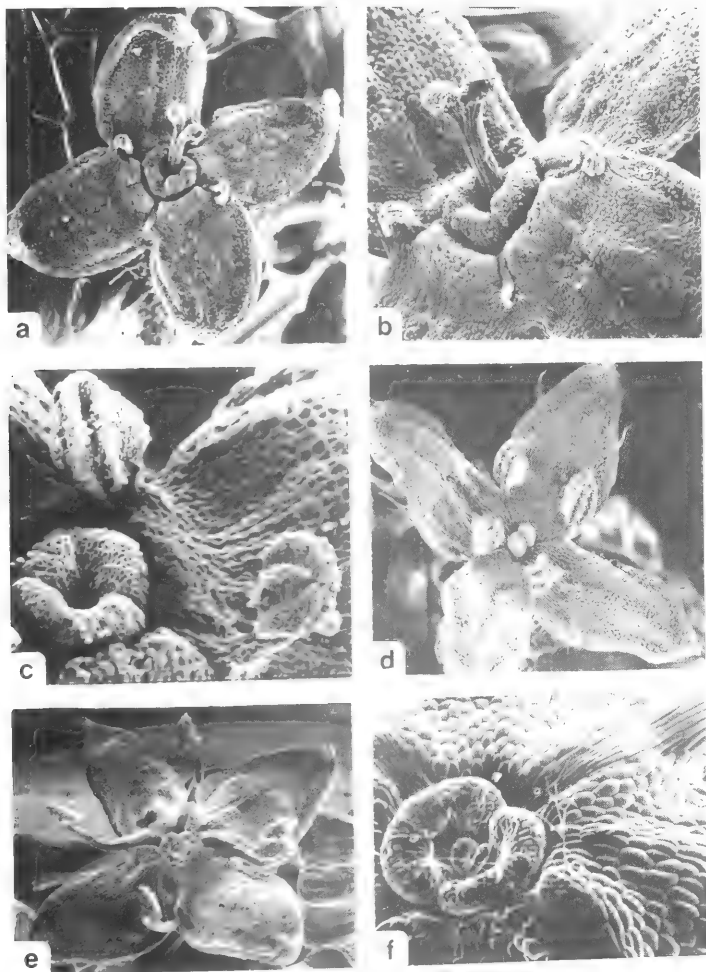


FIG. 8.

Flowers of *G. tomentosum* (a, b: ♀; c: ♂), *G. scabrelloides* (d), and *G. subvillosum* (e, f). a, d, e: $\times 20$; b, f: $\times 60$; c: $\times 80$. Explanations in the text.

corollas may occasionally have a purple tinge (sun-exposed specimens?; corollas normally creamy yellow). The calyx is always completely reduced. The two-lobed disk (superimposed on the 2-carpellate inferior ovary) is usually more or less massive (cf. Fig. 8f). The 4 stamens are nearly as long as the corolla lobes (*G. mucroniferum*, *G. subvillosum*: Fig. 8e) or much shorter (less than half as long as the corolla lobes: *G. scabrelloides*: Fig. 8d; even shorter in *G. tomentosum* ♂: Fig. 8c); the anthers are usually more or less elliptic. The styles are fused to the middle (or at least $\frac{1}{3}$), the free ends often arch downward; the stigmas are always capitate.

Fruits

The fruits consist of two mericarps which are globose to subglobose (most Southern African taxa, cf. Figs 9 and 10 a–d) or more or less reniform (*G. tomentosum*: Fig. 10f). They are always dry (never fleshy). Their surface can be glabrous (usually more or less granulate: *G. tomentosum*, Fig. 10e, for example) or covered with white, stiff, hooked hairs which are tuberculate (on a distinct elevation of the skin tissue: cf. Moore, 1975; *G. thunbergianum*, Fig. 9a, b, for example) or non-tuberculate (*G. spurium* ssp. *africanum*, Fig. 9c, d, for example; wrinkles in the skin, however, may occasionally simulate tubercles). In *G. chloroionanthum* (Fig. 9e, f) the hooked hairs are always brown and appear to be flattened at least on herbarium material; no fresh material was available. The mericarp surface can also be covered with (more or less long) straight, white spreading hairs (*G. scabrelloides*, Fig. 10a, b: tuberculate), very short, straight hairs (*G. subvillosum*, Fig. 10c, d), or short, more or less curled hairs (*G. capense* ssp. *garipense*; occasionally in *G. tomentosum*, cf. Fig. 10f). Sometimes only one carpel develops into a fruit. In this case the hairs are much more closely spaced on the aborted carpel than on the fertile one (cf. Figs 10c and 10d): obviously the hairs are initiated at a very early stage of development and become more widely spaced as a result of fruit diameter increase during development.

G. tomentosum has mericarps with three distinct grooves (cf. Fig. 10e), a feature absent from all other Southern African species.

Mericarp size (diameter of a single mericarp) ranges from (0,7)0,8–1(1,2) mm (*G. amatymbicum*) to (2)2,5–3,5 mm (*G. undulatum*, for example).

POLLINATION BIOLOGY

All Southern African taxa with the possible exception of the annual *G. spurium* ssp. *africanum* (autogamous?) appear to be entomogamous. Field observations are fragmentary, but small insects (small flies, not precisely identified) were at least observed on flowers of *G. tomentosum* (♂ and ♀ plants), *G. scabrelloides* and *G. capense* ssp. *garipense*. The flowers of the last two were found to be strongly scented. Flowers of *G. thunbergianum*, *G. capense* ssp. *garipense*, *G. scabrelloides*, *G. subvillosum* and *G. mucroniferum* that were investigated in the field

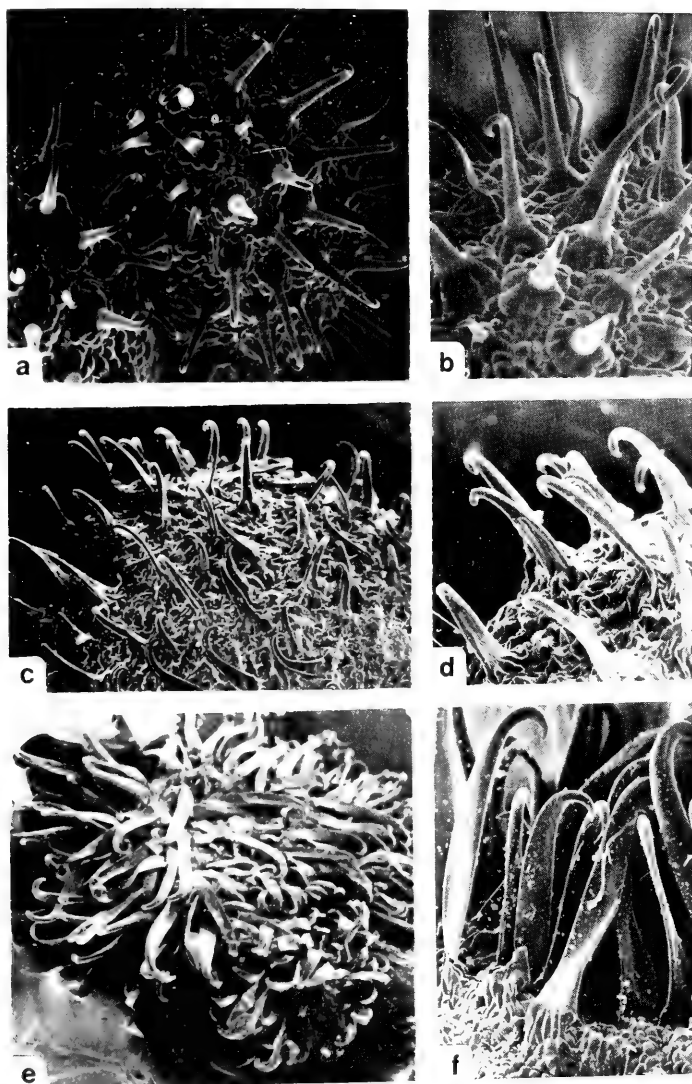


FIG. 9.

Fruits of *G. thunbergianum* (a, b), *G. spurium* ssp. *africanum* (c, d), and *G. chloroionanthum* (e, f). a, c: $\times 25$; d, b: $\times 100$; e: $\times 30$; f: $\times 120$. Explanations in the text.

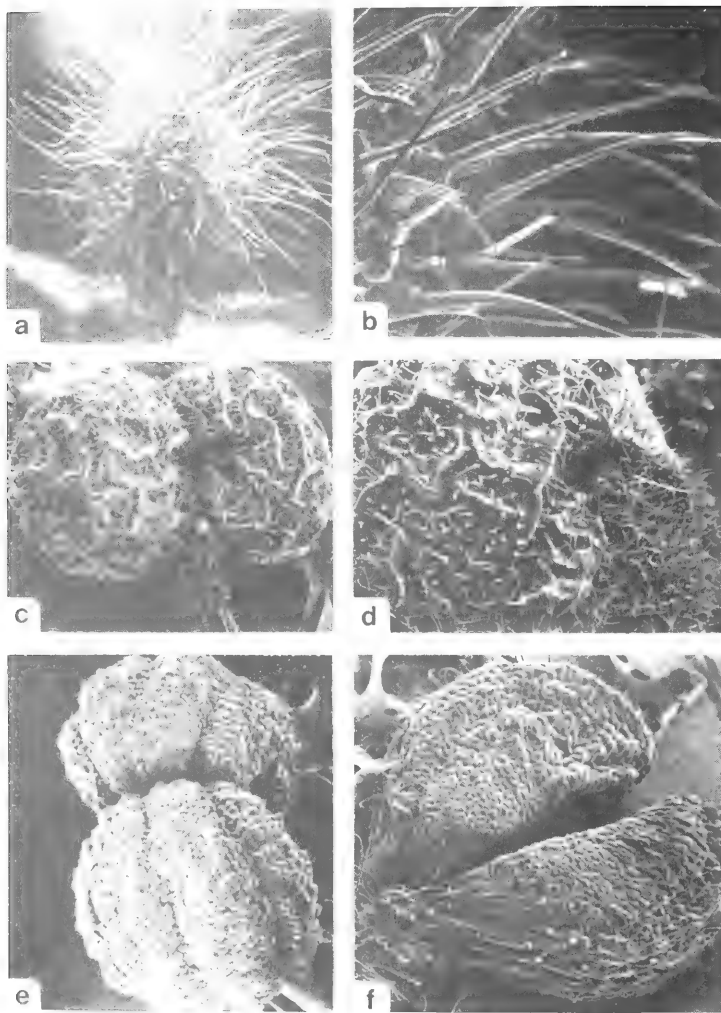


FIG. 10.
Fruits of *G. scabrelloides* (a, b), *G. subvillosum* var. *subvillosum* (c, d), and *G. tomentosum* (e, f). a: $\times 30$; b: $\times 200$; c: $\times 10$; d: $\times 30$; e, f: $\times 20$. Explanations in the text.



FIG. 11.

Schematic representation of mechanism preventing self-pollination in *G. subvillosum*. Further explanations in the text.

were found to produce nectar in profusion; only in *G. spurium* ssp. *africanum* do the tiny disks apparently produce very little nectar. *G. capense* ssp. *garipense*, *G. scabrelloides* and *G. thunbergianum* have slightly protandrous flowers. In *G. mucroniferum* and *G. subvillosum*, however, protandry is particularly pronounced (Fig. 11): pollen is released as soon as the flower opens (Fig. 11a). After one or two days the filaments begin to move into a more or less horizontal position; at this stage stigmas are not yet fully developed, and the styles have not yet elongated ("male state" of the flower, Fig. 11b; also see Fig. 8e, f). After approximately three days the styles slowly begin elongating (Fig. 11c); four to six days after the opening of the flower the styles have reached their full length, and the stigmas are ready for pollination ("female state" of the flower). Meanwhile the filaments have bent down below the level of the corolla lobes (the anthers by now are empty or almost empty; Fig. 11d).¹

Similar mechanisms promoting allogamy have already been recorded for other *Galium* species by Müller (1873, Fig. 135: *G. verum*) and Kirchner (1911, Fig. 37: *G. mollugo*).

DELIMITATION OF THE GENUS

The genus *Galium* L. belongs to the tribe *Rubieae*. The only other genus of this tribe represented in Southern Africa is *Rubia* with the taxa *R. cordifolia* L. ssp. *conotricha* (Gandoger) Verdc., *R. petiolaris* DC., *R. horrida* (Thunb.) Puff (recently transferred from *Galium*: Puff, 1978), and the introduced *R. peregrina* L. (according to Sonder, 1865; no specimens seen by me). It is distinguished from *Galium* (as far as Southern African material is concerned) by much longer leaves with well developed petioles (excluding *R. peregrina*), 5-merous corollas and more or less fleshy fruits.

TAXONOMY

Galium L.²

Perennial herbs or annuals. Stems more or less distinctly 4-angled (sometimes more or less terete near the base), glabrous or beset with hairs or reversed prickles. Leaves and leaf-like stipules in whorls of 4–10, epetiolate. Synflorescences many-

¹ Based on observations of plants cultivated in a garden in Pietermaritzburg. Results were consistent in all plants examined.

² Description valid only for the Southern African members of the genus.

to few-flowered. Flowers perfect, or imperfect (plants dioecious); corollas 4-merous, rotate, yellow to whitish; calyx absent; stamina 4, as long as or shorter than the corolla lobes; ovary inferior, stigmas capitate; fruits consisting of two globose, subglobose or more or less reniform mericarps, dry, glabrous or with hooked or straight hairs.

KEY TO THE SPECIES AND SUBSPECIES

1. Middle cauline leaves in whorls of 4, 3-nerved 1. *G. thunbergianum* N. & S. Afr. Bot.
- Middle cauline leaves in whorls of 6–10, 1-nerved 2
2. Synflorescences very reduced, paracladia with one or two groups of 3–1 flowers ... 3
- Synflorescences \pm extensive, paracladia many-flowered 8
3. Leaves large, up to 38(45) mm long and (12)15 mm wide, with reversed prickles on the margins; fruits with hooked hairs 4
- Leaves small, up to 14 mm long and 3 mm wide, without prickles on the margins; fruits glabrous or with straight, not hooked hairs 5
4. Fruit hairs brownish, ca. 1 mm long, flattened, very densely spaced; pedicels 0.5–1 mm long 13. *G. chloroionanthum* Trop. Afr.
- Fruit hairs white, less than 0.5 mm long, not flattened, well spaced; pedicels (8)12–20(35) mm long 14. *G. spurium* ssp. *africanum* Trop. Afr.
5. Leaves large, up to 14 mm long and 3 mm wide; longest internodes 10–45(55) mm; fruiting pedicels up to 10(13) mm long; corolla (2.5)3–4 mm in diameter 6
- Leaves small, up to 5(6) mm long and 1.2 mm wide; longest internodes 1–10(15) mm; fruiting pedicels up to 1(2) mm long; corolla 1.5–2 mm in diameter 7
6. Paracladia with 3–6 flowers arranged in groups of 3; fruiting pedicels (3)4–6(8) mm long 9. *G. subvillosum* S.W. Afr.
- Paracladia with 2–4 flowers arranged in groups of 2; fruiting pedicels (4)6–10(13) mm long 10. *G. mucroniferum* S.W. Afr.
7. Longest internodes 1–5(6) mm; leaves up to 2.5 mm long, glabrous; paracladia 3–1-flowered 4. *G. bredasdorpense* Breda. C.
- Longest internodes 8–10(15) mm; leaves up to 5(6) mm, with \pm long, white spreading hairs; paracladia only 1-flowered 5. *G. amatymbicum* E. Afr.
8. Flowers imperfect, plants dioecious, peduncles and pedicels villous 12. *G. tomentosum* S.W. Afr. Cape
- Flowers perfect, peduncles and pedicels glabrous, scabrous, or with a few, \pm straight white hairs, but never villous 9
9. Leaves obovate to obovate-oblong, (6)8–10(11) mm wide, often glaucous, always in whorls of 6; flowers with very short stamina (anthers almost sessile) 11. *G. undulatum* Cape S. Afr. N. & S. Afr. Bot.
- Leaves linear, lanceolate or (narrowly) oblanceolate, (0.6)0.8–4(5) mm wide, never glaucous, in whorls of 6–8–10; flowers with stamina ca. half as long as the corolla lobes 10
10. Leaves with densely set reversed prickles on the margin; pedicels hairy with \pm long, straight white hairs or glabrous 11
- Leaf margins glabrous, with \pm long, straight white hairs or only very few, small reversed prickles; pedicels glabrous or scabrous 12
11. Longest internodes (25)30–65(75) mm; mericarps typically hairy with straight, white hairs; leaves up to 4(5) mm wide; South Africa, Lesotho, Swaziland 7. *G. scabrelloides* N. & S. Afr. Bot.
- Longest internodes 20–25 mm; mericarps glabrous; leaves not wider than 2(2.5) mm; from tropical East Africa extending into Rhodesia 8. *G. scabrellum* Trop. Afr.
12. Leaves (18)20–30 mm long; from tropical East Africa extending into Rhodesia 6. *G. bussei* Trop. Afr.
- Leaves (3)5–20(23) mm long; South Africa, Lesotho 13

13. Stems densely covered with short, spreading hairs; leaves 0.6–0.8(1) mm wide, surfaces densely covered with \pm long, white spreading hairs; corolla (1.5)1.7–2(2.3) mm in diameter 3. *G. monticolum*
 Stems glabrous, with minute prickles or very short, curled whitish hairs; leaves (0.3)0.5–2(2.5) mm wide, surfaces smooth or with small, forward-directed prickles or short straight hairs; corolla 2–3.5(4) mm in diameter 14
14. Leaves with small, forward-directed prickles or short, straight hairs on the surfaces; pedicels scabrous (or subglabrous) 2B. *G. capense* ssp. *namaquense*
 Leaves glabrous or with a few reversed prickles on the margin; pedicels always glabrous 15
15. Mericarps glabrous; leaves up to 12(15) mm long 2A. *G. capense* ssp. *capense*
 Mericarps \pm densely covered with short, curled whitish hairs (rarely subglabrous); leaves up to 20(23) mm long 2C. *G. capense* ssp. *garipense*

1. *G. thunbergianum* Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 369 (1836). Type: South Africa, "Ceded Territory" (= SE. Cape Prov.), Katriviersberg, *Ecklon & Zeyher* 2321 (S!, SAM!; NU, WU: photos!).

G. rotundifolium sensu Thunb., Fl. Cap. 1: 551 (1813), non L.

G. rotundifolium sensu Sonder in Fl. Cap. 3: 39 (1865), non L.

G. rotundifolium L. var. *hirsutum* Sond. in Fl. Cap. 3: 39 (1865). Type: South Africa, Cape Prov., *Masson* in herb. Thunberg sub no. 3354 (UPS!; NU, WU: photos!).

G. rotundifolium L. var. *normale* O.Ktze., Rev. Gen. Pl. 3,2: 120 (1898). Type: South Africa, Natal, Van Reenen's Pass, 1800 m, *O. Kuntze* s.n. (K!).

G. dayscarpum Schweinf., Beitr. Fl. Aethiop.: 135 (1867). Type: Ethiopia, Simien, *Debra-Eski*, *Schimper* (B).

G. biafrae Hiern in Fl. Trop. Afr. 3: 245 (1877). Types: Fernando Po, *Mann* 605 & Cameroun Mtn., *Mann* 1284 (both K).

G. natalense Rouy in Fl. Fr. 8: 9 (1903), adnot. Type: South Africa, Natal, Drakensberge, Van Reenen Pass, *Medley Wood* 5562 (LY; K: photo).

Perennial with extensive rhizome. Stems climbing, suberect or procumbent, (80)100–400(600) mm long, with \pm few lateral branches; 0.5–1(1.5) mm in diam., distinctly 4-angled, glabrous or with short, \pm spreading white hairs. Longest internodes (15)25–50(65) mm. Middle cauline leaves in whorls of 4, 3-nerved, (7)10–18(22) \times (3.5)4–8(10) mm, (roundish-)ovate, elliptic or \pm rhombic, \pm acute or with a short hyaline point at the apex, \pm cuneate at the base; glabrous or with short, \pm spreading hairs on both surfaces and on the flat margins. Synflorescences broadly pyramidal to \pm cylindrical, paracladia \pm many-flowered, ultimate branches with 1–2 minute bracts; pedicels 1–3(5) mm, slightly elongating after anthesis, glabrous or hairy, \pm divaricate in fruit. Flowers slightly protandrous, 4-merous; corolla (1)1.5–2.5(3) mm in diam., rotate, often with a few short hairs outside, greenish, greenish-white, pale yellow, or yellow; lobes longer than wide, \pm ovate; stamina ca. half as long as the lobes, filaments \pm filiform, anthers elliptic; styles ca. $\frac{1}{2}$ to $\frac{1}{3}$ fused. Fruits dry, densely covered with white tuberculate hooked hairs; mericarps subglobose, each (0.8)1–1.5 mm wide.

Two varieties recognized:

1a. var. **thunbergianum**

G. natalense Rouy in Fl. Fr. **8**: 9 (1903), adnot. Type: South Africa, Natal, Drakensberge, Van Reenen Pass, *Medley Wood 5562* (LY; K: photo).

G. rotundifolium L. var. *normale* O.Ktze., Rev. Gen. Pl. **3**,2: 120 (1898). Type: South Africa, Natal, Van Reenen's Pass, 1800 m, *O. Kuntze s.n.* (K!).

Stems, leaves, peduncles and pedicels glabrous or nearly so (occasionally a few hairs at some of the upper nodes or along the nerves of the leaves).

Chromosome Number: $n = 11$, $2n = 22$.

Habitat: In forest margin vegetation (but rarely in forests), on stream banks, under rock overhangs, or in rocky grassland. Generally in damp to wet, \pm rich soil and sheltered, \pm shady locations. Ca. 900–2 350 m.

Flowering Period: December to March (April).

Distribution (maps, Figs 12, 13): In the mountains of West Kenya and Ethiopia, and Southern Africa (East Rhodesia, East and South Transvaal, Swaziland, Natal, Lesotho, Orange Free State and Eastern Cape Province).

1b. var. **hirsutum** (Sond.) Verdc. in Kew Bull. **30**: 326 (1975).

G. rotundifolium L. var. *hirsutum* Sond. in Fl. Cap. **3**: 39 (1865). Type: South Africa, Cape Prov., *Masson* in herb. Thunberg sub no. 3354 (UPS!; NU, WU: photos!).

G. rotundifolium sensu Thunb., Fl. Cap. **1**: 551 (1813), non L.

G. dayscarpum Schweinf., Beitr. Fl. Aethiop.: 135 (1867). Type: Ethiopia, Simien, Debra-Eski, *Schimper* (B).

G. biafrae Hiern in Fl. Trop. Afr. **3**: 245 (1877). Types: Fernando Po, *Mann 605* & Cameroun Mtn., *Mann 1284* (both K).

Stems (mainly angles), leaves, peduncles and pedicels \pm densely covered with short, straight, \pm spreading white hairs.

Chromosome Number: $n = 11$, $2n = 22$.

Habitat and Flowering Period: As in var. *thunbergianum*.

Distribution (maps, Figs 12, 13): From tropical Africa (Sudan, Ethiopia, Fernando Po, Cameroun: Cameroun Mtn., Zaire, Uganda, Kenya and Tanzania) to Southern Africa, where it occurs in East Rhodesia, North, North East and South Transvaal, Swaziland, Natal, Lesotho, Orange Free State and Eastern Cape Province.

Critical Remarks: While var. *thunbergianum* is very much rarer than var. *hirsutum* in tropical Africa (cf. Verdcourt, 1976), both varieties are more or less equally well represented in Southern Africa. Although they were often found growing side by side in the field, intermediate (\pm hairy) forms were never detected. The subdivision of the species into two varieties, therefore, seems justified.

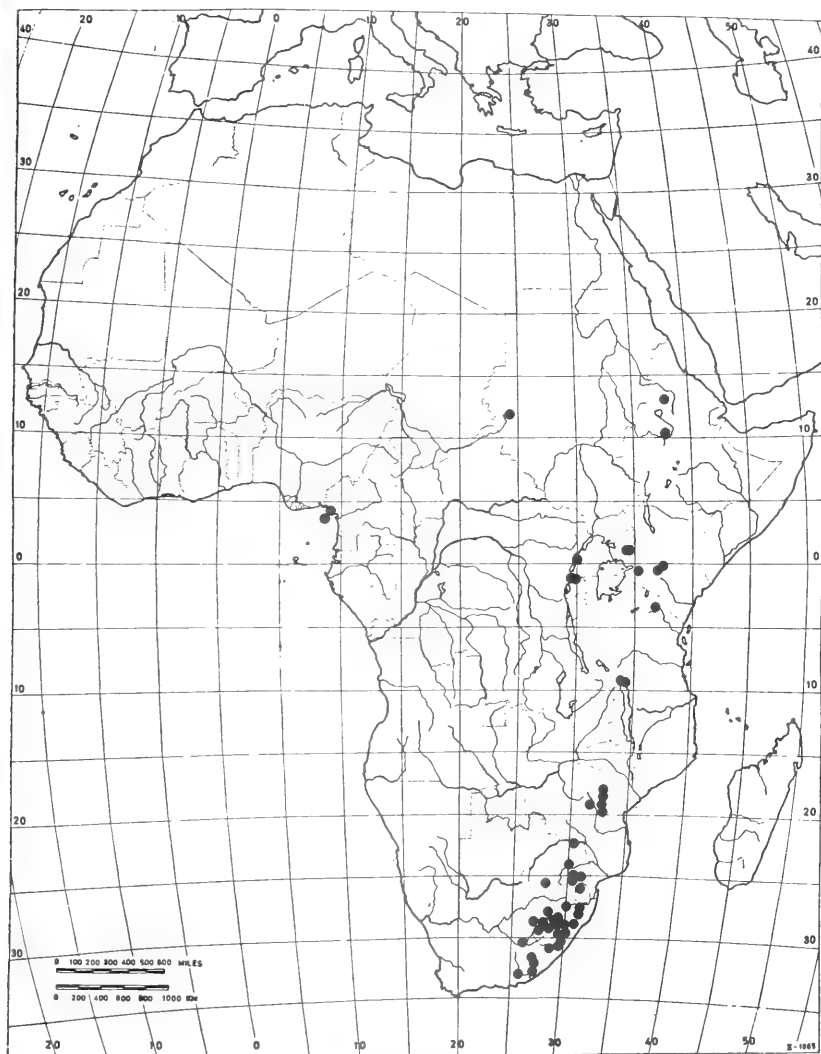


FIG. 12.
Distribution of *G. thunbergianum*
(var. *thunbergianum* and var. *hirsutum*).

G. thunbergianum is very variable, particularly leaf size and shape (cf. Fig. 5b) and extent of the synflorescence may differ greatly. Since variation, however, is considerable even within a single population and leaf and synflorescence variation is not correlated at all, a further subdivision of the species does not seem appropriate.

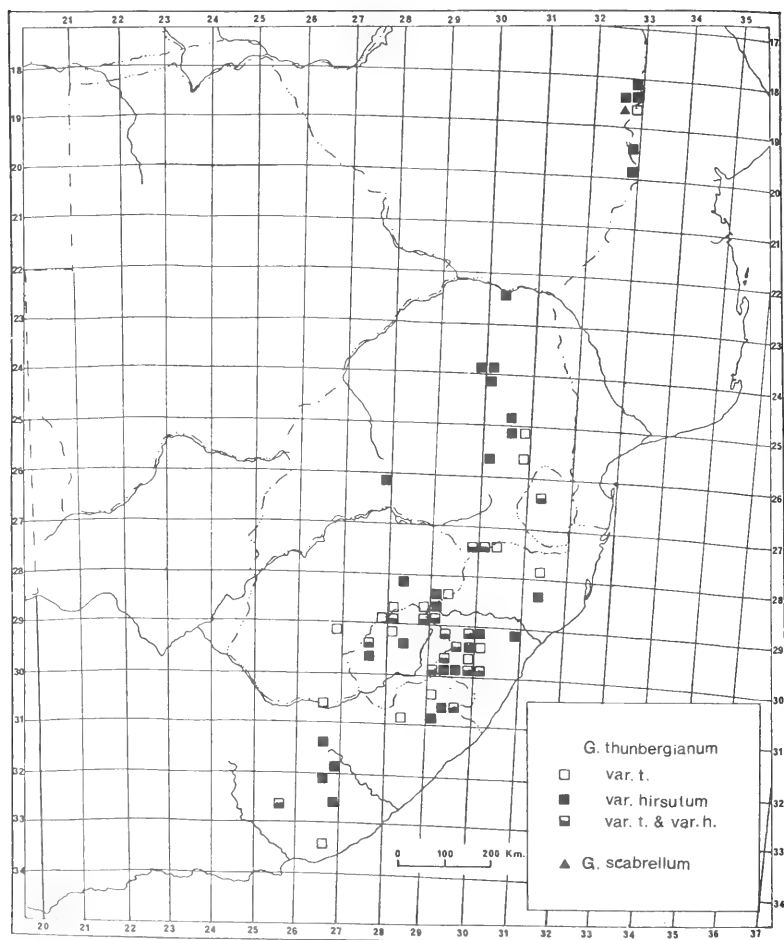


FIG. 13.
Distribution of *G. thunbergianum* var. *thunbergianum* and var. *hirsutum*, and *G. scabrellum* in Southern Africa.

COLLECTIONS

var. *thunbergianum*

RHODESIA—1832: Inyanga distr. Stapleford, Nuza Slopes, ca. 1 830 m (-DB), *Wild 5706* (LISC, SRGH).

TRANSVAAL—2530 (Lydenburg): ca. 3 m from Whiskeyspruit on old Sabie-Lydenburg rd., ca. 1 830 m (-BB), *Meeuse 10331* (PRE, S); 5 m from Kaapsehoop to Ngodwana (-DB), *Buitendag 823* (NBG).

—2729 (Volksrust): Farm "Highlands", Volksrust distr., ca. 1 700 m, *Mogg 7521* (PRE).

—2730 (Vryheid): Wakkerstroom, ca. 1 830 m (-AC), *Beeton 205* (SAM); Farm "Oshoek" nr. Wakkerstroom, ca. 2 000 m, *Devenish 799* (PRE); "South Hill" summit, ca. 2 300 m, *Galpin 9830* (PRE); Kastrol Nek (-AD), *Fitzsimmons & Van Dam 26061* (PRE).

ORANGE FREE STATE—2827 (Senekal): Doorn Kop (-DD), *Burke s.n.* (K), *Zeyher 772* (K).

—2828 (Bethlehem): Farm "Dunelin" nr. Fouriesburg (-CA), *Potts 3088* (NBG, PRE); Witsieshoek (-DB), *Junod 17448* (PRE); Bester's Vlei, ca. 1 500 m, *Bolus 8171* (BOL), *Flanagan 1866* (P, SAM).

—2926 (Bloemfontein): Thaba Nchu Mtn., Cave Kloof forest, ca. 2 100 m (-BB), *Roberts 2284* (PRE).

SWAZILAND—2631 (Mbabane): Hills N of Mbabane, ca. 1 380 m (-AC), *Compton 28691* (PRE, SRGH); Mbabane distr., Duiker Bush, ca. 1 500 m, *Compton 25596* (NBG).

NATAL—2731 (Louwsburg): Ngome (-CD), *Strey 9557* (NH).

—2828 (Bethlehem): Royal Natal National Park, Mont-aux-Sources, Pastures Busch, ca. 1 830 m (-DD), *Bayer & McLean 120* (PRE);—, Tugela valley and Mont-aux-Sources, ca. 1 500–2 000 m, *Humbert 14862* (P), *15015* (P).

—2829 (Harrismith): E of Van Reenen, 1 700 m (-AD), *Jacobsz 1562* (NBG); Van Reenen pass, 1 800 m, *Kuntze s.n.* (K), *Krook 2058* (S), *Medley Wood 5662* (LY); Umlambonja valley (-CC), *Marriott s.n.* sub PRE 22654 (PRE).

—2929 (Underberg): Giant's Castle Game Reserve, "Main Cave" (-AB), *Puff 761221–2/1* (WU); Cathedral Peak Forest Reserve, catchment 9, ca. 1 800–2 000 m, *Puff 760314–4/2* (WU); Cathkin Park, floor of Ndema forest, ca. 1 370 m, *Galpin 11890* (PRE); Bushman's R. nr. Dalton Bridge, ca. 1 400 m (-BB), *Wright, West & Acocks 3* (NH); Loteni Forest Reserve, S branch of Loteni R. (-BC), *Wright 1475* (NU); Farm "Allandale", adjacent to Kamberg Nature Reserve, ca. 2 100 m, *Puff 761220–2/1* (WU); Bamboo Mtn. (-CB), *McLean 681* (NH); nr. Bushmen's Nek Police Post (-CC), *Hilliard & Burt 7985* (E, K, MO, NU, S); Bushmen's Nek nr. Thamathu Cave, ca. 2 300 m, *Hilliard & Burt 8922* (E, K, NU, PRE); Garden Castle Nature Reserve, valley of Umzimkulu R., ca. 1 800 m, *Hilliard & Burt 7897* (E, K, MO, NU); summit of Nhlosane Mtn.,

- nr. Dargle (-DB), *Puff* 761125-3/5 (WU); 3 m from Donnybrook on Ixopo rd., ca. 1 400 m (-DD), *Edwards* 3107 (NU, PRE); Polela, *Medley Wood s.n.* (SAM).
 —2930 (Pietermaritzburg): 6 m from Balgowan/Curry's Post, ca. 1 350 m (-AC), *Moll* 890 (NU, PRE); Keerom, Farm "Cottingham", ca. 1 380 m (-CC), *Strey* 8415 (NH, SRGH).
 —3029 (Kokstad): Weza, Ingeli slopes (-DA), *Strey* 6305 (K, NH, NU);—, Zuurberg, nr. Transkei Border *Puff* 760509-4/5 (WU).
 LESOTHO—2828 (Bethlehem): Leribe, ca. 1 500-1 800 m (-CC), *Dieterlen* 146 (K, PRE, S, SAM); —, Lefi's Kloof on NE slopes of Leribe Plateau, *Phillips* 972 (SAM); —, W slopes of Leribe Plateau, *Phillips* 749 (SAM).
 —2927 (Maseru): Roma, ca. 1680 m (-BC), *Ruch* 1795 (PRE).
 —2928 (Marakabei): Nsututse, ca. 2 440 m (-AA), *Jacoi Guillard* 1242 (PRE).
 Uncertain locality: "S slope in ravine", *Schmitz* 434 (PRE).
 CAPE—3026 (Aliwal North): Aliwal North (-DA), *Hepburn* 279 (GRA).
 —3028 (Matatiele): Potrivier Berg, ca. 1 680 m (-CD), *Galpin* 6650 (BOL, GRA, K, NH, PRE, SAM).
 —3029 (Kokstad): Invenyani nr. Cedarville (-AC), *Bandert* 200 (GRA).
 —3225 (Somerset East): Bosberg, ca. 1 070 m (-DA), *McOwan* 1537 (BOL).
 —3226 (Fort Beaufort): "Ceded Territory", Katriviersberg (-D?), *Ecklon & Zeyher* 2321 (S, SAM).
 —3226 (Grahamstown): Grahamstown (-BC), *Glass* 830 (NBG).
 Uncertain locality: "Cape of Good Hope", *Cooper* 2495 (K).

COLLECTIONS

var. *hirsutum*

- RHODESIA—1832: Inyanga distr., Inyangani Mtns. (-BB), *Norlindh & Weimarck* 5036 (SRGH); —, Inyanga Down (-BC), *Norlindh & Weimarck* 4740 (SRGH); —, Chipungu Falls (-BD), *Chase* 4349 (SRGH).
 —1832/1932: Umtali distr., Engwa, 1 980 m, *Exell, Mendonça & Wild* 306 (LISC, SRGH).
 —1932: Umtali distr., Himalaya Mtns., ca. 1 950 m (-BD), *Wild* 4444 (LISC, SRGH); Melsetter distr., near Bridal Veil Falls (-DD), *Noel* 2437 (LISC, PRE, SRGH).
 TRANSVAAL—2230 (Messina): Hooqe Veld, Pages Hotel (-AC), *Rehmann* 6862 (K).
 —2329 (Pietersburg): Houtboschberg, 2 160 m (-DD), *Schlechter* 4387 (BOL, PRE, S, SAM, W, WU), 4718 (GRA, NBG, S, SAM, W, WU).
 —2330 (Tzaneen): Wolkberg Bosreserwe, path from Wolkberg to the "Knuckles" (-CC), *Puff* 770109-2/3 (WU).
 —2430 (Pilgrim's Rest): The Downs, ca. 1 200 m (-AA), *Junod* 4270 (PRE), 19973 (PRE); Pilgrim's Rest, Black Hill, ca. 2 050 m (-DC), *Galpin s.n.* (BOL).
 —2530 (Lydenburg): Mt. Anderson, 11,5 m W of Sabie (-BA), *Strey* 3042 (PRE, SRGH); Belfast (-CA), *Leedertz* 9205 (PRE).

—2627 (Potchefstroom): Krugersdorp (-BB), *Jenkins* 9263 (PRE).

—2730 (Vryheid): Farm "Oshoek" nr. Wakkerstroom, nr. Natal border (-AC), *Puff* 770102-2/1 (NU, WU).

Uncertain or inexact localities: Warmbad distr., no locality given, *Leipoldt s.n.* sub PRE 42009 (PRE); Waterberg distr., W end of Waterberg Mtns., Farm Groothoek, ca. 1 800 m, *Codd* 3964 (PRE).

ORANGE FREE STATE—2828 (Bethlehem): Bethlehem (-AB), *Potgieter* 21850 (PRE); Bethlehem distr., Farm "Rondehoek", ca. 1 700 m, *Scheepers* 1763 (PRE).

Inexact locality: "OFS", *Cooper* 2497 (E, K).

SWAZILAND—2631 (Mbabane): Hills N of Mbabane, ca. 1 380 m, *Compton* 28691 (NBG).

NATAL—2729 (Volksrust): nr. Charlestown, ca. 1 500–1 800 m (-BD), *Medley Wood* 5566 (GOET); Farm "Glen Atholl" nr. Charlestown and Volksrust, ca. 1 800 m *Smith* 5693 (PRE); Majuba, *Rogers* 3310 (PRE).

—2730 (Vryheid): Vryheid distr., Farm Kambula, *Gersner* 4632 (PRE).

—2828 (Bethlehem): Royal Natal National Park (-DD), Mont-aux Sources, *Steyn* 1061 (NBG), ca. 1 800 m, *Bayer & McClean* 120 (PRE), ca. 2 000 m, *Mogg* 4247 (PRE), ca. 2 150 m, *Sim s.n.* sub PRE 42007 (PRE); —, Tugela valley and Mont-aux-Sources, ca. 1 600 m, *Humbert* 14846 (P).

—2829 (Harrismith): Olivershoek pass, ca. 1 500 m (-CA), *Wood* 3558 (BOL, E, NH, SAM), *Strey* 9526 (NH); Cathedral Peak area (-CC), *Esterhuysen* 10232 (BOL).

—2831 (Nkandla): Ulundi, ca. 1 500–1 800 m (-AD), *Evans* 486 (NH).

—2929 (Underberg): Giant's Castle Game Reserve, nr. "Barne's Shelter" (-AB), *Puff* 761212-1/2 (WU); Cathedral Peak Forest Reserve, Forest Research Station, catchment 3, ca. 1 900 m, *Killick* 1358 (BOL, NH), —, catchment 9, ca. 1 800–2 000 m, *Puff* 76031-1/1, —2/1 (WU); Cathkin Peak, ca. 1 400 m, *Galpin s.n.* (BOL); nr. Champagne Castle Hotel, ca. 1 650 m, *Acocks* 10067 (NU, PRE); Bushman's R, nr. Dalton Bridge, ca. 1 400 m (-BB), *Wright, West & Acocks* 3 (BOL); South Downs, ca. 1 500–1 800 m (-BB), *Evans* 514A (NH); Game Pass Farm, Gladstone's Nose ridge, at "Game Pass" bushmen shelter, ca. 1 800 m (-BC), *Puff* 760418-1/4 (NU, WU), —1/5 (NU, WU); Farm Allandale, adjacent to Kamberg Nature Reserve, ca. 1 900–2 000 m, *Puff* 761220-1/1 (WU); Kamberg, ca. 2 000–2 100 m (-BD), *Wright* 1784 (NU), 2116 (NU), *Puff* 761219-5/1 (WU); Bamboo Mtn. (-CB), *Grice s.n.* (NU); Bushmen's Nek, nr. Thamathu Cave, ca. 2 300 m (-CC), *Hilliard & Burt* 8922 (E, K, NU, PRE); Garden Castle Nature Reserve, valley of Umzimkulu R., ca. 1 800 m, *Hilliard & Burt* 7897 (E, K, MO, NU); Castle Gardens, *Solomon* 50 (NU); Underberg (-CD), *McClean* 598 (NH); Coleford Nature Reserve, "Sunnyside Cottage", *Puff* 761225-1/1 (WU); Marwaga Mtn., Farm "Sunset" (-DC), *Rennie* 502 (NU); Bulwer-Donnybrook rd. (-DD), *Hilliard & Burt* 8036 (E, K, MO, NU, PRE, S).

—2930 (Pietermaritzburg): Weston ("Westtown") (-AA), *Rehmann* 7345 (K); Elandskop, Farm "Strathavon", ca. 1 500 m (-BB), *Ward* 7645 (NU); Keerom (-CC), *Strey* 10874 (NH), 10833 (NH, NU); Mooirivier distr., *Johnston* 578 (E), 816 (E).

—3029 (Kokstad): Weza, Zuurborg, nr. Transkei border (-DA), *Puff* 760509-1/7 (NU, WU).

Inexact localities: "Natal and Zululand", *Gerrard* 1338 (K, W; as "Port Natal", *Gerrard & M'Ken* 1338 in S); "Natal", *Cooper* 2496 (E, K).

LESOTHO—2828 (Bethlehem): Leribe, ca. 1 500-1 800 m (-CC), *Dieterlen* 146 (K, NH, PRE, SAM); —, mountain slopes S of Mission Station, *Phillips* 688 (PRE, SAM); —, W slopes of Leribe Plateau, *Phillips* 749 (SAM).

—2927 (Maseru): Mazenod (-BC), *Jacot Guillarmod* 799 (PRE); Morija (-DA), *Page* 15964 (BOL).

—2928 (Marakabei): Bokong Stores, ca. 2 350 m (-AC), *Jacot Guillarmod* 160 (PRE).

—2929 (Underberg): Sani Pass-Mokhotlong rd., base of Black Mtn. (-CB), *Puff* 761209-7/12 (WU); Sehlabathebe, 2 300-2 500 m (-CC), *Jacot Guillarmod*, *Getcliffe & Mzamane* 315 (GRA, PRE).

CAPE—3029 (Kokstad): Kokstad, ca. 1 520 m (-CB), *Mogg* 5190 (PRE); Insiswa Mtn., 2 000 m (-CC), *Schlechter* 6450 (W, WU), *Krook* 2056 (W), 10595 (PRE).

—3126 (Queenstown): Stormberg, Penhoek Pass, ca. 1 830 m (-BC), *Acocks* 18668 (PRE, SRGH); summit of Hangklip Mtn., ca. 2 100 m (-DD), *Roberts* 2046 (PRE).

—3225 (Somerset East): near Somerset East (-DA), *Scott Elliot* 357 (E); Bosberg, ca. 910 m, *McOwan* 1414 (BOL).

—3226 (Fort Beaufort): mountain top at Oxtun, ca. 1 460 m (-BA), *Galpin* 8360 (GRA, PRE); Keiskammahoe-Hogsback rd., ca. 2 m from Hogsback village (-DB), *Puff* 760904-1/1 (WU).

Uncertain localities: "Cala district", *Pegler* 1793 (PRE); "Faku's Territory", *Sutherland s.n.* (K).

2. ***G. capense*** Thunb., *Prod. Pl. Cap.* 1: 30 (1794). Type: South Africa, Cape Prov. ("CBS"), *Thunberg* in herb. Thunberg sub no. 3308 (UPS!; NU, WU: photos!).

G. mucronatum Thunb., *Prod. Pl. Cap.* 1: 30 (1794). Type: South Africa, Cape Prov. ("CBS"), *Thunberg* in herb. Thunberg sub no. 3342 (UPS!; NU, WU: photos!).

G. expansum Thunb., *Prod. Pl. Cap.* 1: 30 (1794). Type: South Africa, Cape Prov. ("CBS"), *Thunberg* in herb. Thunberg sub no. 3312 (UPS!; NU, WU: photos!).

G. capense var. *expansum* (Thunb.) Sond. in *Fl. Cap.* 3: 36 (1865).

G. expansum var. *elongatum* Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 370 (1836). Type: South Africa, Cape Prov., between "Hassaquaskloof" and "Breederivier", *Ecklon & Zeyher* 2326 β (BOL!, SAM!; WU: photo!).

G. mucronatum var. *densiflorum* Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 370 (1836). Type: South Africa, Cape Prov., "Vierentwintig Rivieren", *Ecklon & Zeyher* 2327 β (GOET!, P!, SAM!, W!; WU: photo!).

G. mucronatum var. *subglabrum* Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 370 (1836). Type: South Africa, "Tambukiland" (= Eastern Cape Prov.), on the right side of the "Keyrivier" (= Kei R.), *Ecklon & Zeyher* 2327 γ (GOET!, P! SAM!, W!; WU: photo!).

G. namaquense Eckl. & Zeyh., Enum. F. Afr. Austr.: 369 (1836). Type: South Africa, Cape Prov. near "Heerelogramment" (Heerenlogement), *Ecklon & Zeyher* 2322 (S!, SAM!; WU: photo!).

G. garipense Sond. in Fl. Cap. 3: 37 (1865). Types: South Africa, Cape Prov., "on the Garip near Buffelvallei", 4 000 ft., *Drège* (?= *Drège* 7674, K!, S!, W!); —, Natal, "Buffaloerivier", *Gerr. & M'K.* (?= Port Natal, *Gerrard & McKen* 1340 in S!; as Natal & Zululand, *Gerrard* 1340 in K!).

G. wittbergense Sond. in Fl. Cap. 3: 37 (1865). Type: South Africa, Cape Prov., "rocky wet places in the Wittbergen", 6–7 000 ft. Jan. *Drège* (in herbarium Sonder).

G. capense var. *minus* Sond. in Fl. Cap. 3: 36 (1865). Types: South Africa, Cape Prov. ("CBS"), *Thunberg* in herb. *Thunberg* sub no. 3342 (UPS!; NU, WU: photos!); —, —, Wolvekop, *Zeyher* 773 (S!).

G. capense var. *scabrum* Sond. in Fl. Cap. 3: 37 (1865). Types: South Africa, Cape Prov., Modderfonteinsberg, 4 000–5 000 ft., *Drège* 7682 (E!, K!, P!, S!; WU: photo!); —, —, between Pedroskloof and "Lilly Fontein" (Leliefontein), 3 000–4 000 ft., *Drège* 7683 (K!, P!; WU: photo!).

G. wittbergense var. *glabrum* Phillips in Ann. S. Afr. Mus. 16: 113 (1917). Types: Lesotho, Leribe, *Phillips* 713 (K!, SAM!); —, —, *Dieterlen* 40 p.p. (SAM!, mixed with var. *wittbergense*).

Perennial with a sometimes slightly woody rootstock. Stems scrambling, sprawling or climbing, or ascending to erect, (80)150–900 mm long, with a few to many lateral branches; up to 4 mm in diam. and \pm terete at the base, 0.5–3 mm in diam. and distinctly 4-angled in the mid-stem region; glabrous or with a few minute reversed prickles, or with \pm short curled whitish hairs. Longest internodes (8)10–40 mm. Middle cauline leaves in whorls of 6–8(–10), 1-nerved, (3)5–20(23) \times (0.3)0.5–2(2.5) mm, linear to narrowly lanceolate or oblanceolate, with a sometimes brownish-white mucro at the apex; surface sometimes shiny, glabrous or with small, forwardly directed prickles, or with short, straight hairs; margins often reflexed, glabrous or with a few reversed prickles. Synflorescences broadly pyramidal to \pm cylindrical, paracladia \pm many-flowered, flowers arranged in

groups of (15)12–3(1), ultimate branches with (4)3–1 small, linear bracts or ebracteate; peduncles (1)1,5–3 mm, glabrous or scabrous, pedicels (1)1,5–4(5) mm, \pm filiform, glabrous or scabrous, divaricate in fruit. Flowers 4-merous; corolla 2–4 mm in diam., rotate, (bright) yellow, creamy yellow, greenish-yellow or (rarely) whitish; lobes (much) longer than wide, acute or sometimes slightly acuminate; stamina ca. $\frac{1}{4}$ to $\frac{3}{4}$ of lobe length, filaments filiform; styles $\frac{1}{2}$ to $\frac{3}{4}$ fused. Fruits dry, glabrous, \pm tuberculate or granulate, or beset with short straight or curled whitish hairs; mericarps subglobose, each ca. 1–2 mm wide.

Preliminary Remarks:

Sonder's (1865) and my treatment of *Galium* differ considerably in regard to the delimitation of *G. capense*: according to Sonder the *Galium capense* "complex" consists of *G. capense* (with 4 varieties), *G. garipense* Sond. and *G. wittbergense* Sond.; in the present revision, however, *G. capense* is split up into three subspecies:

2A. ssp. *capense*

2B. ssp. *namaquense* (Eckl. & Zeyh.) Puff, and

2C. ssp. *garipense* (Sond.) Puff, with

2Ca. var. *garipense* and

2Cb. var. *wittbergense* (Sond.) Puff

G. capense var. *scabrum* Sond. (= *G. namaquense* Eckl. & Zeyh.) becomes *G. capense* ssp. *namaquense*: although sometimes difficult to keep apart morphologically from ssp. *capense*, it is separated geographically from the latter. *G. capense* s.str. is not subdivided further: all infraspecific names used by Sonder and other early authors are dropped because they stand for indistinguishable morphological forms. *G. garipense* cannot be kept apart specifically from *G. capense* s.str. (particularly in the Eastern Cape Province), and therefore is treated as the "Eastern" subspecies of the *G. capense* "complex". *G. wittbergense*, on the other hand, merely differs from ssp. *garipense* in its hairiness and has a \pm identical distribution range: it is, therefore, considered a variety of ssp. *garipense*.

2A. *G. capense* ssp. *capense*

Type: see 2. *G. capense* Thunb.

G. mucronatum Thunb., Prod. Pl. Cap. 1: 30 (1794). Type: South Africa, Cape Prov. ("CBS"), *Thunberg* in herb. Thunberg sub no. 3342 (UPS!; NU, WU: photos!).

G. expansum Thunb., Prod. Pl. Cap. 1: 30 (1794). Type: South Africa, Cape Prov. ("CBS"), *Thunberg* in herb. Thunberg sub no. 3312 (UPS!; NU, WU: photos!).

G. capense var. *expansum* (Thunb.) Sond. in Fl. Cap. 3: 36 (1865).

G. expansum var. *elongatum* Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 370 (1836). Type: South Africa, Cape Prov., between "Hassaquaskloof" and "Brederivier", *Ecklon & Zeyher* 2326 β (BOL!, SAM!; WU: photo!).

G. mucronatum var. *densiflorum* Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 370 (1836). Type: South Africa, Cape Prov., "Vierentwintig Rivieren", *Ecklon & Zeyher* 2327 β (GOET!, P!, SAM!, W!; WU: photo!).

G. capense var. *minus* Sond. in Fl. Cap. 3: 36 (1865). Types: South Africa, Cape Prov. ("CBS"), *Thunberg* in herb. *Thunberg* sub no. 3342 (UPS!; NU, WU: photos!); —, —, *Wolvekop*, *Zeyher* 773 (S!).

Perennial with a \pm woody rootstock. Stems scrambling or climbing, (80)150–500(700) mm long, with few to many lateral branches; up to 4 mm in diam. and \pm terete at the base, 0.5–1.5(2.5) mm in diam. and distinctly 4-angled in the mid-stem region, (at least younger parts) densely covered with short, curled, whitish hairs; often purplish. Longest internodes (8)10–35(40) mm. Middle cauline leaves in whorls of (6–)8(–10), 1-nerved, (3)5–12(15) \times 0.5–1.5(2) mm, linear to narrowly lanceolate or oblanceolate, with a brownish-white mucro at the apex; surfaces often shiny, glabrous or occasionally with a few reversed prickles on the (strongly) reflexed margins. Synflorescences broadly pyramidal to \pm cylindrical, paracladia usually many-flowered, flowers arranged in groups of (12)9–3(1), ultimate branches with (4)2–1 small bracts or ebracteate; peduncles (1)1.5–3 mm, glabrous, pedicels (1)2–4(5) mm, \pm filiform, glabrous, usually strongly divaricate in fruit. Flowers 4-merous; corolla (2)2.5–4 mm in diam., rotate, bright to pale yellow; lobes much longer than wide, acute or sometimes slightly acuminate; stamens ca. half as long as the lobes, filaments thin; styles fused to the middle. Fruits dry, glabrous, \pm tuberculate or granulate; mericarps subglobose, each ca. 1 mm wide.

Chromosome Number: Unknown. Diploid according to pollen measurements (cf. Fig. 2).

Habitat: In rocky grassland, in kloofs under rock overhangs, on ledges; sometimes in moist ground near watercourses. Usually in sheltered locations. Ca. 200–1 500(1 700) m.

Flowering Period: (August) September to December (January).

Distribution (map, Fig. 14): From the South West Cape extending to the Eastern Cape Province; also in Little, Great and Upper Karoo.

Critical Remarks: The morphological variability of ssp. *capense* is reflected in the large number of synonyms. They merely refer to weakish, rather atypical plants (*G. capense* var. *minus*) or to forms characterized by \pm lax, broadly pyramidal synflorescences and long internodes (*G. expansum*, *G. capense* var. *expansum*, *G. expansum* var. *elongatum*) or \pm dense, narrow synflorescences and short internodes (*G. mucronatum* var. *densiflorum*). As all these (extreme) forms are connected to each other by a series of morphological intermediates, it does not seem justified to uphold them taxonomically. The fairly uniform pollen diameters of morphologically rather divergent forms (Fig. 2b)—a good indication that one ploidy level prevails (presumably diploids; compare with pollen diameters of ssp.

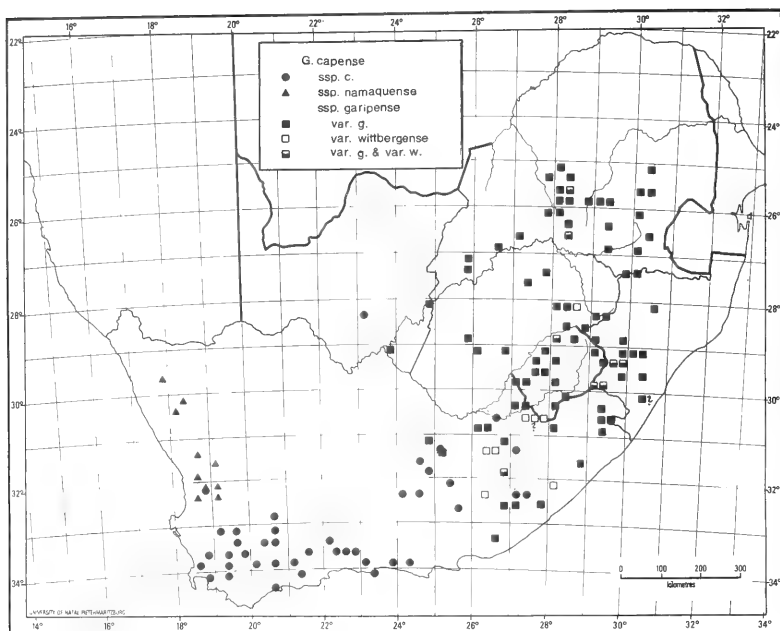


FIG. 14.

Distribution of *G. capense* ssp. *capense*, ssp. *namaquense*, and ssp. *garipense* var. *garipense* and var. *wittbergense*. Question marks: uncertain localities.

garipense)—are an additional argument against a further subdivision of ssp. *capense*.

For occasional problems encountered in delimiting ssp. *capense* from ssp. *namaquense* and ssp. *garipense* refer to the "Critical Remarks" section of the latter.

COLLECTIONS

CAPE—2823 (Griekwastad): at Bloem's Fontein (= Grootfontein) (-AC), *Burchell* 2640 (GOET, K, P).

—3026 (Aliwal North): Eland's Hoek nr. Aliwal North, ca. 1 400 m (-DA), *Bolus* 143 (BOL).

—3124 (Hanover): Richmond, Roelofsfontein (-DA), *Hanekom* 1937 (PRE). Wapadsberg pass (-DD), *Maguire* 715 (NBG).

—3125 (Steynsburg): nr. Middelburg (-AC), *Acocks* 5536 (S).

—3126 (Queenstown): Molteno distr., Looperberg, ca. 1 600 m, *Mogg* 2771 (PRE).

- 3127 (Lady Frere): Clarksdale, Dordrecht (-AC), *Taylor* 5648 (NBG).
- 3218 (Clanwilliam): Clanwilliam (-BB), *Zeyher* s.n. (K).
- 3220 (Sutherland): Klein Roggeveld, Oranjerfontein, ca. 1 450 m (-DC), *Bond* 17 (NBG); Sutherland distr., Vertaten Kloof (?spelling), *Adamson* D130 (PRE).
- 3224 (Graaff-Reinet): 25 m W of Graaff-Reinet, ca. 1 500–1 800 m (-AC), *Acocks* 15865 (PRE; atypical); nr. Graaff-Reinet, ca. 700 m (-BC), *Bolus* 139 (BOL, PRE); between Graaff-Reinet and Mussupburg, ca. 1 500–1 800 m, *Bolus* (?) 225 (BOL).
- 3225 (Somerset East): Mountain Zebra National Park (-AB), *Brynard* 150 (PRE); Bosberg, ca. 1 450 m (-DA), *Tofel* (?spelling) 416 (PRE).
- 3227 (Stutterheim): ca. 7 m from Hogsback-Cathcart rd., Happy Valley, ca. 1 500 m (-AC), *Johnson* 1268 (GRA); banks of Toise R., ca. 820 m (-AD), *Acocks* 9413 (PRE).
- 3318 (Cape Town): Paarlberg, ca. 300–600 m (-DB), *Drège* s.n. ("G. expansum Thunb.", E, K, P, S, W); Kanon Berg (-DC), *Salter* 6447 (BOL, K); Tigerberg, Nov. 38, no collector given (?Ecklon) (W).
- 3319 (Worcester): Winterhoekberg, ca. 300–600 m (-AA), *Drège* 7680 (K, W); Vierentwintig Rivieren, *Ecklon & Zeyher* 2327 β (GOET, P, SAM, W); Baviaansberg (-BA), *Stokoe* s.n. sub SAM 70003 (SAM), sub PRE 41989 (PRE), ca. 1 680 m, *Bond* 1451 (NBG); between Hottentotskloof and Karroopoort (-BA, -BC), *Pearson* 4818 (B, BOL, K); Hex R. Mtns., Prospect Peak (-BC), *Esterhuysen* 15962 (BOL, PRE); Brandvlei, ca. 360 m (-CB), *Levyns* 10775 (NBG); Worcester, 300 m, *Marloth* 12560 (PRE); between Worcester and Villiersdorp, ca. 510 m (-CB, -CD), *Bolus* 5061 (BOL); Louwshoek Mtn. (-CD), *Stokoe* s.n. sub SAM 59533 (SAM); Hex R. valley nr. De Doorns *Bolus* 13123 (BOL); Boschjesveld nr. Mordkuil, on the Doorn R., below 300 m, *Drège* 7685 (E, K, P, W); Koo (-DB), *Compton* 3890 (BOL, NBG); Eendragt pass nr. Koo, ca. 1 070 m, *Levyns* 7977 (BOL); Worcester distr., Andensberg, *Esterhuysen* 3259 (BOL), *Compton* 9743 (NBG);—, Keeromsberg, *Esterhuysen* 9187 (BOL); Ceres distr., Bokkeveld Tafelberg, *Esterhuysen* s.n. sub BOL 31401 (BOL).
- 3320 (Montagu): Pieter Meintjes, 1 150 m (-AD), *Marloth* 10777 (PRE); Bantams, ca. 900 m (-BA), *Compton* 12141 (NBG); Witteberg S of Bantams, ca. 1 370 m, *Esterhuysen* 30488 (BOL); Matjiesfontein, Witteberg, ca. 1 070 m, *Compton* 2806 (BOL, NBG); Witteberg, ca. 1 220 m, *Adamson* s.n. (BOL, K); Dobbelaars Kloof, ca. 760 m (-BC), *Levyns* 6718 (BOL); Malagas, *Esterhuysen* 4451 (NBG, PRE); Bonnievale, ca. 425 m (-CC), *Levyns* 4589 (BOL); nr. Barrydale on Montagu rd., ca. 700 m (-DC), *Levyns* 573 (BOL).
- 3321 (Ladismith): Between Litte Vetter R. and Garcia's pass (-CC), *Burchell* 6926 (K); W of Rooiberg pass, ca. 1 070 m (-DA), *Willems* 1639 (NBG); Rooiberg pass, *Wurts* 1611 (NBG); Swartberg, slopes below Kariegasberg, 1 300 m, *Thompson* 2179 (PRE).

—3322 (Oudtshoorn): Swartberg pass (-AC), *Stokoe* 8645 (BOL), ca. 1 030 m, *Wall* 340 (S), *Acocks* 1429 (S); —, 11 m E from top, ca. 1 370 m, *Stokoe s.n.* sub SAM 67539 (PRE, SAM); Langekloof, ca. 600–1 200 m (-CB), *Ecklon & Zeyher* “100–12” (S); Kommassie Mtns. (“Komanatsie Hills”) (-DA, -DB), *Prior s.n.* (K).

—3323 (Willowmore): Brandhoek, on rd. from Kouga R., ca. 460 m (-CC), *Fourcade* 5092 (BOL); Joubertina (-DD), *Horn s.n.* sub PRE 41964 (PRE).

—3324 (Steytlerville): on Kouga R., rd. from Suuranys (“Zuur Amys”), ca. 275 m (-CD), *Fourcade* 3100 (BOL).

—3418 (Simonstown): Steenbras (-BB), *Rogers* 17860 (PRE); Hottentots-Holland, *Gueinzus s.n.* (S); Hottentotsholland Kloof (= Sir Lowry's Pass), *Ecklon & Zeyher* 2327 (W).

—3419 (Caledon): nr. Caledon (-AB), *Esterhuysen* 4404 (BOL); Caledon Distr., *Cruse* 49 (S).

—3420 (Bredasdorp): Malagas (-BC), *Esterhuysen* 4451 (NBG, PRE).

—3421 (Riversdale): nr. Riversdale (-AB), ca. 180 m, *Muir* 2942 (PRE), ca. 210 m, *Schlechter* 1877 (GRA, PRE).

—3423 (Knysna): Plettenberg Bay (-AB), *Pappe s.n.* (K, S).

Uncertain, inexact or doubtful localities: Between “Hassaquaskloof” and “Breederivier”, *Ecklon & Zeyher* 2326 β (BOL, SAM); Wolvekop, *Zeyher* 773 (S); from Tulbaghskloof (Nieuwekloof) to Pikenierskloof, ca. 150–300 m, *Drège* “140.10” (E); between Montagu and Triangle, *Barnard s.n.* sub SAM 32714 (SAM); in the Houthoek Mtns. and hills between Gauritz R. and Langekloof, *Ecklon* 1836, 2326 (GOET, WU); between Swellendam and George, *Mundt* (*Ecklon & Zeyher*) 91 (S); on the Fish R., ca. 1 370 m, *MacOwan* 1627 (SAM); Stockenstrom, *Scott Elliot* 344 (E); between Brakrivier and Uitvlugt, ca. 900–1 200 m, *Drège* 7679 (K, P); “Kaffirland”, *Barber s.n.* (S); “Regio orientalis” or “CBS”, *Sparman s.n.* (S), *Thunberg s.n.* (P, S), *Dahl s.n.* (S), *Prior s.n.* (K), *Thorn s.n.* (K), *Thorn* 357 (K), *Scott Elliott s.n.* (E), *Meyer s.n.* (GOET); highly doubtful: Port Natal, *Gueinzus s.n.* (W); Durban, Natal, *Kassner* 1716 (E).

2B. ssp. **namaquense** (Eckl. & Zeyh.) Puff, stat. nov.

G. namaquense Eckl. & Zeyh., Enum. Fl. Afr. Austr.: 369 (1836). Type: South Africa, Cape Prov., near “Heerelogement” (Heerenlogement), *Ecklon & Zeyher* 2322 (S!, SAM!; WU: photo!).

G. capense var. *scabrum* Sond. in Fl. Cap. 3: 37 (1865). Types: South Africa, Cape Prov., Modderfonteinsberg, 4 000–5 000 ft., *Drège* 7682 (E!, K!, P!, S!; WU: photo!); —, —, between Pedroskloof and “Lilly Fontein” (Leliefontein), 3 000–4 000 ft., *Drège* 7683 (K!, P!; WU: photo!).

Perennial with a slightly woody rootstock. Stems scrambling or sprawling, (150) 300–900 mm long, generally much-branched; 1–3 mm in diam., \pm terete at

the base, otherwise distinctly 4-angled, densely covered with very short, usually curled whitish hairs; often purplish. Longest internodes (20)25–40 mm. Middle cauline leaves in whorls of 6–8, 1-nerved, (4)6–8(10) × (0,5)1–2(2,5) mm, linear to narrowly lanceolate or oblanceolate, with a brownish-white mucro at the apex; upper and (sometimes) lower surface and margins (densely) covered with small, forwardly directed prickles or short, straight hairs; margins often reflexed. Synflorescences broadly pyramidal to cylindrical, paracladia ± many-flowered, flowers arranged in groups of (9)6–3, ultimate branches with 3–1 tiny, linear bracts; peduncles 1,5–2,5 mm, scabrous, pedicels (1)1,5–3(4) mm, ± filiform, scabrous or more rarely subglabrous, divaricate after anthesis. Flowers 4-merous; corolla (2)2,5–3,5 mm in diam., rotate, yellow or greenish-yellow; lobes longer than wide, acute; stamina short, ca. $\frac{1}{4}$ to $\frac{1}{2}$ of lobe length, filaments filiform; styles short, fused to the middle. Fruits dry, beset with short, straight whitish hairs or glabrous, ± tuberculate or granulate; mericarps subglobose, each 1–2 mm wide.

Chromosome Number: Unknown. Diploid according to pollen measurements (cf. Fig. 2).

Habitat: Scrambling in dense vegetation of river banks, in arid fynbos, Renosterveld, or *Erica*-bush. Frequently in shady, ± sheltered locations and sandy soils. Ca. 725–1 500 m.

Flowering Period: (August, September) October to December.

Distribution (map, Fig. 14): Endemic to the Western Cape Province.

Critical Remarks: Although the morphological distinction between the polymorphic ssp. *namaquense* and ssp. *capense* may occasionally become rather difficult (sometimes indumentum is the only "good" separation character), it was decided to follow Ehrendorfer's (1952, unpublished) suggestions on sheets from the herbaria K and P to treat "*namaquense*" as a subspecies of *G. capense*. Its distinct and ± closed area of distribution (with hardly any overlap with ssp. *capense*) supports the subspecies rank rather than varietal status (the latter would possibly have been more appropriate if the taxon had been sufficiently scattered geographically).

COLLECTIONS

CAPE—2917 (Springbok): Modderfonteinsberg (-DB), Drège 7682 (E, K, P, S, W).

—3018 (Kamiesberg): SW of Leliefontein (-AB), Pearson 6302 (K); between Pedrosdorp and Leliefontein, ca. 900–1 200 m, Drège 7683 (K, P, W); between Leliefontein and Ezelsfonteins, ca. 1 380 m (-AB, -AC), Pearson 6319 (B, BOL; appr. ssp. *capense*); between Ezelsfontein and Kamiesberg, ca. 1 520 m, Adamson 1470 (BOL, PRE; appr. ssp. *capense*); Kamiesbergen, Elliotsberg (-AC), Cramp-ton 7699 (BOL).

—3118 (Vanrhynsdorp): Giftberg, ca. 760 m (-BC), Esterhuysen 22068 (BOL); Heerenlogement (-DC), Ecklon & Zeyher 2322 (S, SAM).

—3119 (Calvinia): Lokenburg, 21 m S of Nieuwoudtville, ca. 760 m (-CA), *Story 4390* (GRA, PRE); ca. 1130 m, *Acocks 17374* (K, PRE).

—3218 (Clanwilliam): Pakhuis pass (-BB), *Salter 5042* (K), *Compton 4761* (NBG), *Thode A2119* (K, PRE); E base of Piquetberg (-BC), *Pillans 8641* (BOL, PRE; appr. ssp. *capense*).

—3219 (Wuppertal): Cedarberg, path to Middelberg plateau, ca. 850 m (-AA, -AC), *Levyns 2227* (BOL); —, Middelberg, *Bond 1327* (NBG), *Esterhuysen s.n.* sub NBG 23363 (NBG), 2487 (BOL), 2517 (PRE); —, Metjiesrivier, *Wagener 292* (NBG); Algeria Nature Reserve, Cedarberg, slopes of Vensterkop, ca. 730 m, *Taylor 7485* (PRE); Cedarberg Forest Reserve, NE base of Sneeuberg, ca. 900–1 200 m (-AC), *Taylor 6184* (PRE).

2C. ssp. **garipense** (Sond.) Puff, stat. nov.

G. garipense Sond. in Fl. Cap. 3: 37 (1865). Types: South Africa, Cape Prov., “on the Garip near Buffelvallei”, 4 000 ft., *Drège* (? = *Drège 7674*, K!, S!, W!); —, Natal, “Buffaloerivier”, *Gerr. & M’K.* (? = Port Natal, *Gerrard & Mc’Ken 1340* in S!; as Natal & Zululand, *Gerrard 1340* in K!). See “Critical Remarks”.

Perennial with a sometimes \pm woody rootstock. Stems usually ascending to erect, (100)200–500(600) mm long, normally with \pm few lateral branches; up to 3 mm in diam. and \pm terete at the base, 0.8–2 mm in diam. and with 4 distinct, whitish angles in the mid-stem region; glabrous, with a few minute reversed prickles on the angles or with \pm short, whitish hairs. Longest internodes 10–30(40) mm. Middle cauline leaves in whorls of 6–8, 1-nerved, (6)8–20(23) \times (0.3)0.5–1(1.5) mm, linear, often with a \pm distinct mucro at the apex; glabrous or sometimes with a few small reversed prickles on the often \pm reflexed margin. Synflorescences broadly pyramidal to \pm cylindrical, paracladia \pm many-flowered, flowers arranged in groups of (15)12–3, ultimate branches with 1–2 small, linear bracts; peduncles 1.5–2.5 mm, glabrous, pedicels (1)1.5–3(4) mm, \pm filiform, glabrous, divaricate in fruit. Flowers slightly protandrous, 4-merous; corolla 2–3.5(4) mm in diam., rotate, bright yellow, sometimes creamy-yellow, yellow-green or (rarely) whitish, lobes longer than wide, acute; stamina ca. $\frac{3}{4}$ of lobe length, filaments filiform; styles $\frac{1}{2}$ to $\frac{3}{4}$ fused. Fruits dry, \pm densely covered with short, curled whitish hairs (rarely subglabrous); mericarps \pm globose, each 1–1.8 mm wide.

Two varieties recognized:

2Ca. var. **garipense**

G. mucronatum var. *subglabrum* Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 370 (1836). Type: South Africa, “Tambukiland” (= Eastern Cape Prov.), on the right side of the “Keyrivier” (= Kei R.), *Ecklon & Zeyher 2327* (GOET!, P!, SAM!, W!; WU: photo!).

G. wittbergense var. *glabrum* Phillips in Ann. S. Afr. Mus. 16: 113 (1917).
Types: Lesotho, Leribe, Phillips 713 (K!, SAM!); —, —, Dieterlen 40 p.p.
(SAM!, mixed with var. *wittbergense*).

Stems glabrous or occasionally with a few minute, reversed prickles on the angles. *? Can have a few prickles on the angles of the stems.*
Chromosome Number: $n = 11$, $2n = 22$. *large may be required for this*

Habitat: In vleis, along stream banks, on steep, well-drained (moist) rocky slopes, or in open grassland; sometimes in disturbed ground (road-sides, etc.). Usually in sun-exposed situations or in semi-shade. Ca. (500)1 100–3 000 m.

Flowering Period: (September) October to January (February).

Distribution (map, Fig. 14): From the Transvaal, Orange Free State, Lesotho, Natal Midlands and Uplands, Griqualand East and Transkei to the Eastern Cape Province.

2Cb. var. **wittbergense** (Sond.) Puff, stat. nov.

G. wittbergense Sond. in Fl. Cap. 3: 37 (1865). Type: South Africa, Cape Prov., "rocky wet places in the Wittbergen", 6–7 000 ft. Jan. Drège (in herbarium Sonder; see "Critical Remarks").

Stems hairy, but without minute prickles on the angles. *... Distig*
Chromosome Number: $n = 11$, $2n = 22$.

Habitat and Flowering Period: as in var. *garipense*.

Distribution (map, Fig. 14): From the Transvaal, South East Orange Free State, North Lesotho, Natal Midlands and Uplands to the Eastern Cape Province.

Critical Remarks: It is somewhat uncertain which specimens are to be considered the valid types of *G. garipense*: Sonder (1865) lists "on the Garip near Buffelvallei, 4 000 ft., Dec. Drège" as type. No *Galium*, however, was collected there by Drège (cf. Drège 1843, p. 50). Specimen Drège 7674 ("Kraairivier, am und im Fluss, 4 500 Fuss, Januar"), on the other hand, is from a nearby locality and, moreover, corresponds well with the original description of *G. garipense*. It therefore seems likely that Sonder confused these two collecting sites (on specimen Drège 7674 from the herbarium S the name "*Galium garipense* Sond." was written on the label by Sonder himself!). The second type is "Buffaloerivier, Gerr. & M'K.": this may well refer to the specimens Gerrard & McKen 1340 and Gerrard 1340 (in *Flora Capensis*, Sonder often for some inexplicable reason omitted collection numbers). These two specimens are probably from one collection: in several herbaria collections by Gerrard & McKen are often attributed to Gerrard only. The locality given for these identical specimens is either "Port Natal" on one set of labels or "Natal & Zululand" on another. The assumption that this collection is indeed a type is supported by the fact that the label of the Gerrard & McKen specimen from the herbarium S was written by Sonder himself. However, on the label he filled in "Port Natal" as locality and not "Buffaloerivier" as given in *Flora Capensis*.

The type of *G. wittbergense* originates from "rocky, wet places in the Wittbergen, 6–7 000 ft. Jan. Drège". According to Drège (1843, p. 52) this must be collection site I a. 54 ("Witbergen, an feuchten Oertern, grasreichen Thälern und in Felsschluchten, 6 000–7 000 Fuss, Januar") and specimen Drège 7676. I have been unable to trace this specimen. Although Sonder mentions that it is in his own herbarium, Dr. J. Ross (personal communication) could not find the collection at the herbarium MEL, where most of Sonder's herbarium is housed.

While specimens of *garipense* from more Eastern localities (Transvaal, Natal) are always clearly distinct from *G. capense* s.str., separation of the two taxa becomes rather troublesome where their ranges of distribution overlap (Eastern Cape Province). For that reason alone species status cannot be maintained for *garipense*. The latter is also not specifically distinct from *G. wittbergense*. Differential characters for the two taxa given by Sonder (1865, p. 37: *G. garipense* has "more diffuse habit, glabrous, often prickly stems, smaller spreading or reflexed leaves, and longer cymes") are not valid: after examination of ample herbarium material it becomes obvious that all these characters are variable. It would therefore seem best to reduce *wittbergense* to varietal rank and to include it in ssp. *garipense*.

G. capense ssp. *garipense*, like the other infraspecific taxa, is extremely variable in habit, branching pattern, internode length and extent of the synflorescence. Some forms (belonging to either of the two varieties) produce glabrescent gynoecea or fruits instead of hairy ones, and may therefore rather closely resemble ssp. *capense*.

A number of specimens from West Natal¹ differ from ssp. *garipense* (and ssp. *capense*) in having very many short lateral branches with internodes shorter than 10 mm, needle-like (not more than 0.5 mm wide) erect to spreading leaves arranged in whorls of (8–)10 and \pm smaller flowers (not more than ca. 2 mm in diam.). As their position is not at present clearly understood, they have not been given formal recognition.

COLLECTIONS

ssp. *garipense* var. *garipense*

TRANSVAAL—2527 (Rustenburg): Bokfontein (-DB), Jenkins 7545 (PRE).
—2528 (Pretoria): Apiesrivier, 1 600 m (-AA, -AD), Rehmann 4241 (K), Schlechter 3633 (BOL, PRE, SAM, W; \pm atypical); Fairy Glen, ca. 1 460 m (-CA), Mogg 17230 (PRE, SRGH); Pretoria, Leendertz 3736 (PRE); Onderstepoort, Theiler 9604 (PRE); Silverton (-CB), Obermeyer 146 (PRE); between

¹ 2929 (Underberg): Coleford Nature Reserve. "Sunnyside Cottage", ca. 1 500 m (-CD), Moll 5157 (NH), Puff 761225-2/1 (WU); Polela distr., Sunset, Lot 7, Marwaga Mtn., ca. 2 000 m (-DC), Rennie 268 (NU).

Baviaanspoort and Vlaktefontein (Mamelodi), ca. 1 370 m, *Smith* 1078 (PRE); Irene (-CC), *Burt Davy* 734 (PRE), *Obermeyer* 123 (PRE), *Rogers* 11416 (K), 8661 (PRE), *Leendertz* 668 (PRE); Rietvlei Reserve, ca. 1 520 m (-CD), *Repton* 3251 (PRE); 16 m SE of Pretoria on rd. to Delmas, ca. 1 520 m, *Codd* 3457 (PRE).

—2529 (Witbank): Witbank, ca. 1 610 m (-CC), *Rogers* 24302 (GRA); Middelburg (-CD), *Jenkins* 9859 (PRE); —, on the Klein Olifantrivier, *Du Plessis* 842 (PRE), *Young* A78 (PRE).

—2530 (Lydenburg): Nr. Lydenburg (-AB), *Wilms* 574 (E, K); Belfast (-CA), *Williams* 10252 (PRE); Waterval Boven (-CB), *Britten* 4752 (PRE).

—2626 (Klerksdorp): Klerksdorp (-DC), *Convent* 30 (GRA).

—2627 (Potchefstroom): Witkoppen (-BB), Pharmac. Lab., Univ. Witwatersrand 4691 (K); Isaac Stegmann Nature Reserve, 1 713 m, *Mogg* 35478 (PRE); Potchefstroom (-CA), *Louw* 776 (PRE); Potchefstroom distr., Laerberg, *Theron* 828 (PRE).

—2628 (Johannesburg): Johannesburg (-AA), *Moss* 8538 (BOL), *Leendertz* 6190 (PRE); Modderfontein, *Conrath* 353 (K); Germiston, *Rogers* 12107 (PRE); Heidelberg (-AD), *Leendertz* 7727 (PRE); Lagersport nr. Heidelberg, *Crosser* 1567 (PRE); Farm "Wetter" (Schoongezicht 64), ca. 1 580–1 760 m (-AD?), *Mogg* 24167 (SRGH); Suikerbosrand, ca. 1 680 m (-AD, -CA), *Bredenkamp* 990 (PRE), *Repton* 5358 (PRE); 18 m E of Vereeniging, Visgat, ca. 1 520 m (-CA), *Codd* 4465 (PRE).

—2629 (Bethal): Bethal (-AD), *Leendertz* 9381 (PRE); Standerton (-CD), *Leendertz* 11004 (PRE).

—2630 (Carolina): Carolina (-AA), *Rademacher* 7276 (PRE); Spitskop (-CB), *Pott* 15162 (PRE); ca. 21 m E of Amersfoort on Piet Retief rd. (-CC), *Puff* 770103-1/1 (NU, WU); Carolina distr., Farm "Bergendal", ca. 1 640 m, *Galpin s.n.* sub PRE 12498 (BOL, PRE).

—2725 (Bloemhof): Leeufontein, 10 km W of Wolmaranstad (-BB), *Van Wyk* 729 (PRE); Boskuil, ca. 1 300 m (-BD), *Sutton* 238 (PRE).

—2729 (Volksrust): Volksrust (-BD), *Jenkins* 9315 (PRE).

—2730 (Vryheid): Farm "Oshoek" nr. Wakkerstroom, ca. 2 000 m (-AC), *Devenish* 440 (PRE), 1238 (K, NH), *Puff* 770102-1/1 (NU, WU).

Uncertain localities: Kolonie Plaats, *Burt Davy* 9096 (PRE); P.P. Rust, *Rogers* 2376 (PRE).

ORANGE FREE STATE—2727 (Kroonstad): Heilbron, banks of Vaal R., ca. 1 450 m (-BD), *Brandmüller* 140 (NBG, PRE); Kroonstad distr., nr. Vals R., ca. 1 370 m (-CB), *Pott* 427 (PRE); Kroonstad distr., Farm "Rondavel Noord 1475", ca. 1 340 m, *Scheepers* 1718 (PRE).

—2728 (Frankfort): Senekal distr., Doornkop, *Goosens* 641 (PRE; ± atypical).

—2825 (Boshof): Krugersdrift Nature Reserve, ca. 1 380 m (-DD), *Müller* 1334 (PRE).

—2828 (Bethlehem): embankment of Bethlehem-Kroonstad railway line (Bethlehem distr.), ca. 1 500 m (-AA), *Potgieter 40* (PRE: \pm atypical); nr. Bethlehem, ca. 1 500 m (-AB), *Flanagan 2089* (PRE), *Bolus 8172* (BOL); 6 m from Bethlehem on Kestell rd., ca. 1 700 m, *Werger 25* (PRE); Arran nr. Skulpspruit, ca. 1 700 m, *Werger 105* (PRE, SRGH); Clarens (-CB), *Van Hoepen 18186* (PRE); Witsieshoek (-DB), *Junod 17478* (PRE).

—2829 (Harrismith): Drakensberg and Eastern O.F.S. Botanic Gardens, ca. 1 700 m (-AC), *Jacobsz 1030* (PRE), 2076 (NBG), *Van der Zeyde s.n.* sub PRE 41947 (NBG, PRE, SRGH); Harrismith, *Sankey 82* (K); Swinburne, Rensburgskop (-AD), *Jacobsz 178* (PRE).

—2925 (Jagersfontein): Fauresmith distr., Groenvlei, *Verdoorn 1050* (PRE).

—2926 (Bloemfontein): Bloemfontein, ca. 1 380 m (-AA), *Potts 433* (BOL), 1091 (PRE), *Hanekom 831* (PRE); —, O.F.S. Botanic Garden, *Müller 412* (NBG); Wintervally N of Bloemfontein, *Müller 421* (PRE); Thaba Nchu Mtn. (-BB), *Roberts 2346* (PRE; \pm atypical).

—3027 (Lady Grey): Zastron (-AC), *Maree 92* (PRE, \pm atypical).

Uncertain or inexact localities: between Bloemfontein and Brandfort, *Acocks 8264* (S); Kafferfontein, *Kies 316* (PRE).

NATAL—2729 (Volksrust): Newcastle Distr., Farm “Boscobello” (-BD), *Jenkins 12468* (PRE).

—2829 (Harrismith: Van Reenen, ca. 1 680 m (-AD), *Medley Wood 12110* (BOL, NU, SAM), *Franks* sub *Medley Wood 12110* (NH), *Bews 228* (NU); Van Reenen pass, ca. 1 500 m, *Medley Wood 945* (E); nr. Winterton (-CC), *King 1* (PRE); Farm “Brakfontein” nr. Frere, ca. 1 070 m (-DD), *Acocks 10843* (NH).

—2830 (Dundee): Vant’s Drift, ca. 1 070 m (-BA), *Codd 2388* (PRE).

—2929 (Underberg): summit plateau of Drakensberg nr. Giant’s Castle pass, ca. 3 000 m (-AD), *Wright 1152* (E, NU, PRE; \pm atypical); Estcourt, ca. 1 200 m (-BB), *West 1829* (NH); Mooi River (-BC), *Johnston 146* (E), *Medley Wood 3562* (K, NH, SAM); —, banks of Mooi R. nr. Lake Hotel (-BC), *Johnston 707* (E); hills nr. Mooi River, ca. 1 220 m, *Medley Wood 676* (E), *s.n.* (GRA); Meteor Ridge, ca. 1 450 m, *Mogg 3326* (PRE), 8087 (PRE); Kamberg Nature Reserve, Stillerust Vlei, *Puff 761218-1/1* (WU), *-2/1* (WU), *-1/3* (WU); Farm “Game Pass” adjacent to Kamberg Nature Reserve, ca. 1 800 m, *Gordon-Gray 102* (NU); Farm “Allandale” adjacent to Kamberg Nature Reserve, ca. 1 850 m, *Puff 761220-2/3* (NU, WU; \pm atypical), *-3/1* (WU); Kamberg (-BD), *Puff 761219-1/2* (NU, WU) *-2/1* (WU), *-3/2* (NU, WU); Drakensberg Gardens (-CC), *Lawson 978* (NH), 1000 (NH; \pm atypical); —, above Forester’s house, ca. 2 000 m (-CC), *Puff 761226-1/1* (WU); nr. Bushmen’s Nek Police Post, *Hilliard & Burt 7989* (E, K, NU, S); Thamathu pass, ca. 2 300 m, *Hilliard & Burt 8947* (NU; \pm atypical); Coleford Nature Reserve (-CD), *Sidey 3922* (PRE; \pm atypical); Mpendhle, Farm “Tillietudlem”, ca. 1 550 m (-DB), *Huntley 107* (NH, NU). Polela distr., “Glenariff”, ca. 1 500 m, *Rennie 658* (NU; \pm atypical).

—2930 (Pietermaritzburg): Weston (-AA), *Fisher 436* (NH, NU); Rietvlei, Greenwich Farm (-AB), *Fry 2770* (K, PRE); nr. Pietermaritzburg (-CB), *Wilms 2022* (K).

—3029 (Kokstad): Weza, Ingeli slopes (-DA), *Strey 6281* (NH; \pm atypical).

Uncertain, inexact or doubtful localities: "Natal & Zululand", "Port Natal", *Gerrard 1340* (K), *Gerrard & Mc' Ken 1340* (S); Movelo (?Rovelo) Hills, ca. 2 100 m, *Sutherland s.n.* (K); Pietermaritzburg-Drakensberg, *Wahlberg s.n.* (S).

LESOTHO—2828 (Bethlehem): Leribe (-CC), *Dieterlen 40* (K, P, PRE); Ox Bow Camp, ca. 2 600 m (-DC), *Lubke 250* (PRE). \leftarrow = *Wahlberg s.n.*

—2927 (Maseru): Mamathes, ca. 1 700 m (-BB), *Jacot Guillarmod 89* (PRE); Monethe's, ca. 1 700 m, *Jacot Guillarmod 1918* (PRE); Tebetebeng Mill, ca. 1 500 m, *Jacot Guillarmod 357* (PRE); Roma, ca. 1 700 m (-BC), *Ruch 2151* (PRE); Thabana-li-Mele nr. Roma, ca. 2 600 m, *Williamson 340* (K); Mafeteng, ca. 1 700 m (-CC), *Watt & Brandwyk 1924* (PRE); Thaba Tsoeu, ca. 1 700 m (-CD), *Page s.n.* sub BOL 16796 (BOL); Morija (-DA), *Dieterlen 1145* (PRE); between Makhaleng and Nyakasoba, ca. 2 300 m (-DA, -DB), *Jacot Guillarmod 5776* (PRE).

—2928 (Marakabei): nr. Blue Mountain Pass, ca. 1 900 m (-AC), *Williamson 506* (K); Mamalapi, ca. 2 750 m, *Compton 21349* (NBG); Maletsunyane Falls, ca. 2 100 m (-CC), *Staples 173* (PRE).

—2929 (Underberg): Ndumeni Dome and Cleft Peak, ca. 3 000 m (-AA), *Killick 2322* (PRE, SRGH); Mokhotlong, ca. 2 400 m (-AC), *Jacot Guillarmod 1162* (PRE), *Liebenberg 5802* (PRE).

—3028 (Matatiele): Lehaha-la-Sekhonyana, ca. 2 850 m (-AB), *Jacot Guillarmod 183* (PRE).

Uncertain localities: Maseru distr., Ha Khotso, *Songca 23* (PRE); Quthing distr., Mphaki, ca. 2 300 m, *Archibald 520* (GRA); "Lesotho", ca. 2 200 m, *Ruch 1615* (PRE). \leftarrow = *Wahlberg s.n.*

CAPE—2824 (Kimberley): Warrenton (-BB), *Adams 176* (BOL; very atypical). —2923 (Douglas): St. Clair (-BB), *Orpen 79* (NBG); on Vaal R. at confluence of Orange R., *Burchell 1729* (K).

—3026 (Aliwal North): ca. 3,5 m NW of Ontspringen Station, ca. 1 400 m (-CC), *Acoks 13524* (PRE); Burghersdorp, ca. 1 500 m (-CD), *Flanagan 1537* (BOL, PRE; \pm atypical), *Guthrie 4205* (NBG; \pm atypical), *Pocock 10810* (PRE; \pm atypical).

—3027 (Lady Grey): Dulcie's Nek (-AD), *Marais 1344* (PRE, SRGH).

—3028 (Matatiele): Drakensberg, Tsatsana (Satsanna) Peak, ca. 2 850 m (-AC), *Galpin 6652* (BOL, K, PRE; atypical); 20 m W of Mount Fletcher, ca. 1 830 m (-CC), *Story 500* (PRE).

—3029 (Kokstad): St. Bernards (-AA), *Barker 8017* (NBG; \pm atypical); Newmarket (-AD), *Krook 2699* (W; \pm atypical); Kokstad, ca. 1 520 m (-CB), *Coleman 317* (NH), *Mogg 5051* (PRE; \pm atypical), *Goossens 173* (PRE; \pm atypical).

atypical); around Kokstad, ca. 1 520 m, *Tyson 1819* (BOL, K, SAM; atypical), *1991* (BOL, K, PRE, SAM; atypical); nr. Mt. Ayliff, on the Umzimhlawa R. (= Mzimhlava), 1 500 m (-CD), *Schlechter 6551* (S, W; \pm atypical).

—3124 (Hanover): Noupoot (-BB), *Rogers 17322* (K).

—3125 (Steynsburg): Middelburg (-AC), *Theron 203* (PRE).

—3126 (Queenstown): Jamestown, ca. 1 830 m (-BB), *Gerstner 261* (PRE); Berry Reservoir E of Queenstown (-DD), *Hilner 339* (GRA, PRE; appr. var. *wittbergense*).

—3128 (Umtata): Umtata, nr. Umtata R., ca. 730 m (-DB), *Pegler 1602* (K; \pm atypical); between Maclear and Umtata, Cherikwe Mtn., ca. 1 200 m, *Flanagan 2646* (PRE, SAM; \pm atypical), *Bolus s.n.* (BOL; \pm atypical).

—3226 (Port Beaufort): Katberg, ca. 1 830 m (-DA), *Schonland 4290* (GRA), *Sole 408* (GRA).

—3227 (Stutterheim): Hogsback (-CA), *Rattray 433* (PRE); along the Kei R. nr. Komga, ca. 460 m (-DB), *Flanagan 1351* (BOL, NBG, NU, SAM); King William's Town distr., Mount Coke, ca. 600 m, *Sim 19610* (NU, PRE).

—3326 (Grahamstown): Grahamstown (-BC), *Glass 831* (NBG).

Uncertain or inexact localities: Griqualand West, on the Riet R., 1 100 m, *Marloth 906* (PRE); Griqualand East, Vaalbank, *Haygarth s.n.* (E, as *Wood 4217* in K; \pm atypical); Grootfontein, *Gilli 10* (GRA).

COLLECTIONS

ssp. *garipense* var. *wittbergense*

TRANSVAAL—2528 (Pretoria): Derdepoort (-CB), *Leendertz 357* (PRE; \pm atypical).

—2628 (Johannesburg): Suikerbosrand, Kafferskraal, ca. 1 600 m (-CA), *Bredenkamp 86* (PRE).

Uncertain locality: Breginsel, *Burt Davy 1016* (PRE).

ORANGE FREE STATE—2828 (Bethlehem): Kransfontein, ca. 1 680 m (-BA), *Hart 64* (NU).

NATAL—2929 (Underberg): Kamberg Nature Reserve, Stillerust Vlei (-BC), *Hilliard & Burt 8729* (E, K, MO, NU, PRE), *Puff 761218-1/3* (NU, WU); Farm "Allandale", adjacent to Kamberg Nature Reserve, ca. 1 900–2 000 m, *Puff 761220-4/1* (WU); Kamberg (-BD), *Wright 2085* (NU; \pm atypical), *Puff 761219-1/2* (NU, WU), *-2/1* (NU, WU), *-6/1* (WU; \pm atypical); Highmoor Forest Station, ca. 2 070 m (-BD), *Killick & Vahrmeyer 3633* (NH); valley of Umzimkulu R. above Drakensberg Garden Hotel, ca. 1 680 m (-CC), *Hilliard & Burt 7736* (E, K, MO, NU, PRE, S; \pm atypical); Bushman's Nek, Thamathu pass, ca. 2 300 m, *Hilliard & Burt 8946* (NU; appr. var. *garipense*); Coleford Nature Reserve, "Sunnyside Cottage" (-CD), *Puff 761225-2/2* (WU, \pm atypical); —, on the banks of the N'gwangwane R., *Puff 761227-1/1* (NU, WU).

LESOTHO—2828 (Bethlehem): Leribe, ca. 1 500–1 800 m (–CC), *Dieterlen* 40 (SAM).

CAPE—3027 (Lady Grey): Majuba Nek nr. Sterkspruit (–CB), *Hepburn* 148 (GRA); “Cis-Garipinia”, on the Garip (= Oranje), between Kraai R. and Witbergen, ca. 1 500–1 800 m (–DA?), *Zeyher* “118:12” (S); Wittebergen (Witberge), Ben MacDhui, ca. 2 800–3 000 m (–DB), *Galpin* 6651 (BOL, K, PRE).

—3126 (Queenstown): Broughton nr. Molteno, ca. 1 930 m (–AD), *Flanagan* 40 PRE - garipense 1586 (S, SAM); Penhoek pass (–BC), *Barker* 2200 (NBG); Queenstown, Hangklip Mtn., ca. 2 000 m (–DD), *Roberts* 2024 (PRE), —, ca. 1 780 m, *Galpin* 1783 (PRE; appr. var. *garipense*).

—3225 (Somerset East): Cradock distr., *Cooper* 548 (BOL, E, K, W).

—3226 (Fort Beaufort): Groot Winterberg, S of Tarkastad, Farm “Fairfield”, ca. 1 680 m (–AD), *Comins* 787 (PRE).

—3228 (Butterworth): Kotana (–AA), *Lussem* 57 (NBG; ± atypical).

3. *G. monticolum* Sond. in Fl. Cap. 3: 36 (1865). Type: South Africa, Cape Prov., mountains near Cape Town, *Ecklon* 84 (S!; WU: photo!).

Perennial with a ± woody rootstock. Stems ascending to erect, ca. 0.3–1.2 m long, usually with many lateral branches; ca. 2.5 mm in diam., densely covered with short, spreading hairs, distinctly 4-angled, except ± terete near the base; sometimes purplish. Longest internodes 12–17(25) mm. Middle cauline leaves in whorls of (6)–8–10, 1-nerved, 5–8(12) × 0.6–0.8(1) mm, linear, with a long whitish, sometimes upturned mucro at the apex, often apparently terete due to the strongly reflexed margins; upper surface, midrib beneath and margins densely covered with ± long, white spreading hairs. Synflorescences ± cylindrical, paracladia relatively few-flowered, flowers arranged in groups of (5)4–1, ultimate branches with (5)3–1(0) minute, linear hairy bracts; peduncles 0.8–1.5 mm, ± thickish, hairy, pedicels 0.8–1.5(2) mm, filiform, glabrous, divaricate after anthesis. Flowers 4-merous; corolla (1.5)1.7–2(2.3) mm in diam., rotate, colour unknown; lobes longer than wide, acuminate; stamina ca. ¼ of lobe length, anthers roundish; styles short, ca. half or less fused. Young gynoecium glabrous, ± granulate; mature fruits not seen.

Habitat: On mountain slopes, scrambling among bushes.

Flowering Period: October to November.

Distribution (map, Fig. 15): Endemic to the Western Cape.

Critical Remarks: *G. monticolum* is undoubtedly a very close ally of *G. capense* (ssp. *namaquense* and ssp. *capense*). The few collections available clearly differ from the above two subspecies of *G. capense* by their indumentum (± villous), their somewhat fewer-flowered paracladia and smaller flowers and their usually narrower leaves, but are difficult to separate otherwise (partly because *G. capense* is a rather variable species producing a wide range of “forms”). *G. capense* ssp. *namaquense* is probably closest to *G. monticolum*, and grows in the same general

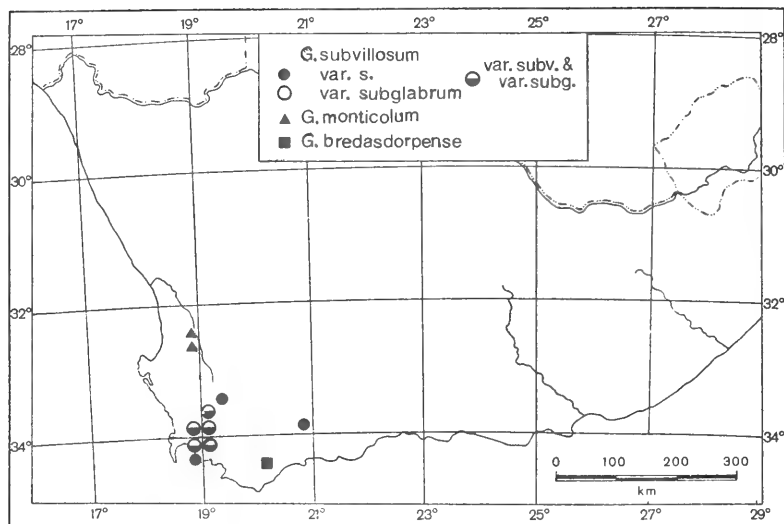


FIG. 15.

Distribution of *G. subvillosum* var. *subvillosum* and var. *subglabrum*, *G. monticolum*, and *G. bredasdorpense*.

area. Much more material of both is needed to see if the characteristics used here to separate them really hold. The status of *G. monticolum* might then need to be reconsidered.

COLLECTIONS

CAPE—3218 (Clanwilliam): between Witte Els Kloof and Lamberts Hoek Berg (-BD), *Pillans 9083* (BOL, PRE); slopes above "Pickinier's Pass" (Piek-enierskloofpas) (-DB), *Pearson 5177* (BOL, K).

Uncertain locality: "Mountains near Cape Town", *Ecklon 84* (S).

4. *G. bredasdorpense* Puff, sp. nov.

Herba perennis, decumbens vel suberecta; caules ca. 150–250 mm longi, ramossissimi, teretiusculi basi, sursum tetragoni, dense scabriosi (saltem rami juniores), internodiis 1–5(6) mm longis. Folia et stipulae foliaceae 6-natim verticillata, sessisila; lamina plus minusve ovato-lanceolata, 1,5–2,5 mm longa, 0,7–1,2 mm lata, apice mucrone albida, nitida, glabra, margine plus minusve reflexa. Cymae axillares, 3(–1)-florae; pedunculi 0,5–1 mm longi, glabri, pedicellis 0,8–2 mm longis, filiformibus, glabris, postfloraliter divaricatis. Corolla rotata, glabra, 1,5–2 mm diam., colore ignoto; lobi 4, plus minusve triangulares, breviter acuminati.

Ovarium glabrum, plus minusve granulatum, subglobosum. Fructus maturus non visus.

Affinis *G. capensi* Thunb. sed foliis brevioribus et internodiis vrevissimis et cymis 3(-1)-floribus axillaribus valde differt.

Perennial. Stems decumbent or suberect, ca. 150–250 mm long, with many lateral branches; 2–2.5 mm in diam. and terete at the base, ca. 0.5–1 mm in diam. and distinctly 4-angled in the mid-stem region; at least younger parts densely scabrous with short, straight whitish hairs. Longest internodes 1–5(6) mm. Middle cauline leaves in whorls of 6, 1-nerved, 1.5–2.5 × 0.7–1.2 mm, ± ovate-lanceolate, with a ± long, whitish mucro at the apex, glabrous, shiny, margin ± reflexed. Synflorescences very reduced, paracladia 3–1-flowered; peduncles 0.5–1 mm, glabrous, pedicels 0.8–2 mm, with 4(-1) leaf-like bracts, filiform, glabrous, divaricate after anthesis. Flowers 4-merous; corolla 1.5–2 mm in diam., rotate, glabrous, colour unknown; lobes much longer than wide, ± triangular, shortly acuminate; stamina ca. half as long as the lobes, filaments filiform, anthers ± ovate; styles ca. ½ fused. Gynoceum glabrous, ± granulate; mature fruit not seen.

Type: South Africa, Cape Prov., Bredasdorp distr., 2 m S of Wydgelegen Post office [= 3420 (Bredasdorp) -AD], *Acocks* 23175 (PRE!; WU: photo!)

Habitat: "In Kalk Coastal Fynbos" (notes from the type collection).

Flowering Period: November to December.

Distribution (map, Fig. 15): Endemic to the limestone formations of the Bredasdorp district.

Critical Remarks: *G. bredasdorpense* seems to be a close ally of *G. capense* (ssp. *capense*), but clearly differs in having very short internodes (frequently shorter than the minute leaves), short, ovate-lanceolate leaves (vs. long, linear in *G. capense*) and highly reduced inflorescences with leaf-like bracts and smaller flowers.

G. bredasdorpense is known only from the type collection, and only the future can tell whether the species is indeed strictly confined to the highly interesting limestone area in the Bredasdorp district¹ which is known to be extremely rich in endemics (Rourke, personal communication, thinks that it would be possible to list well over 100. Exact data, however, are not available).

5. *G. amatymbicum* Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 370 (1836). Type: South Africa, "Tambukiland" (= Eastern Cape Province), on the right side of the "Keyrivier" (Kei R.), *Ecklon & Zeyher* 2328 (GOET!, S!, SAM!; WU: photo!).

Perennial with ± extensive rhizomes. Stems weak, caespitose, ca. 150–300 mm long, with many, often short lateral branches; ± filiform, less than 1 mm in

¹ Acocks (1975) suggests that the "Fynbos" of this area should be considered a distinct veld type of its own ("Kalk Coastal Fynbos").

diam., \pm 4-angled, with \pm long white spreading hairs or glabrous. Longest internodes 8–10(15) mm. Middle cauline leaves in whorls of 6, 1-nerved, (2)3–5(6) \times (0,7)0,8–1 mm, linear-lanceolate to lanceolate, \pm acuminate at the apex; with \pm long white spreading hairs on upper and lower surface or at least on margins and midrib above and beneath. Synflorescences extremely reduced; paracladia only 1-flowered, peduncles/pedicels (0,5)1(2) mm, \pm thickish, hairy or glabrous, \pm arcuate in fruit. Flowers 4-merous; corolla ca. 1,5 mm in diam., \pm rotate, hairy outside, whitish; lobes longer than wide, acute; stamina very short. Fruits dry, with long \pm straight hairs or subglabrous; mericarps \pm reniform, each ca. 1–1,5 mm wide.

Habitat: "In *Acacia* fields" (Ecklon & Zeyher, 1836).

Flowering Period: December.

Distribution (map, Fig. 19): Endemic to the Eastern Cape Province.

Critical Remarks: Although known from two collections only, *G. amatymbicum* is a "good" and well marked species. It is separated from weak forms of *G. capense* (presumably its closest ally) by its solitary flowers in the axils of main-stem whorls or at the end of short lateral branches; from the remaining Southern African taxa with highly reduced synflorescences (*G. spurium* ssp. *africanum*, *G. chloroionanthum*, *G. bredasdorpense*) by its weak stems, minute leaves, very short peduncles/pedicels and its indumentum.

COLLECTIONS

CAPE—3226 (Fort Beaufort): "Tambukiland", on the right side of the "Keyrivier" [= between Windvogelberg and Swartkey: Drège (1847a: 584)] (-BB), Ecklon & Zeyher 2328 (GOET, S, SAM);—, Hogsback Mtn., Gaikas Kop (-DB), Rattray 343 (BOL).

6. *G. bussei* K. Schum. & K. Krause in Bot. Jahrb. **39**: 571 (1907). Type: Tanzania, Songea distr., Ngaka (Mgaka) valley, *Busse 941* (B, EA; K: photo!). *G. stenophyllum* Bak. var. *flavoviride* Uetzsch. & Merxm. in Transact. Rhod. Sc. Ass. **43**: 57 (1951). Type: Rhodesia: Marandellas distr., *Dehn 719A* (SRGH!).

G. stenophyllum auct., non Bak.

Perennial with somewhat woody rootstocks. Stems erect or semi-erect, (200) 300–600 mm long, with usually few, \pm short lateral branches; 1,5–2(2,5) mm in diam., with 4 distinct, often whitish angles with short, \pm spreading hairs or glabrous; nodes usually densely hairy. Longest internodes (15)25–40(55) mm. Middle cauline leaves in whorls of 6–10, 1-nerved, (18)20–30 \times 0,5–1(1,5) mm, linear, often apparently terete due to the strongly reflexed margins, with a distinct brownish acumen at the apex; upper and lower surface with short, \pm spreading hairs, glabrous or with minute, forwardly directed prickles above. Synflorescences

± narrowly cylindrical, paracladia ± many-flowered and dense, ultimate branches with (0)1–4 minute bracts; pedicels 1–1.5 mm, ± filiform, glabrous, strongly divaricate in fruit. Flowers slightly protandrous, 4-merous; corolla 2–2.5(3) mm in diam., rotate, glabrous, yellow, pale yellow or greenish-yellow; lobes longer than wide, ± acuminate; stamina ca. half as long as the lobes, filaments ± filiform, anthers ± elliptic; styles long, ca. ½ fused. Fruits dry, glabrous, ± granulated; mericarps subglobose, each 1.5–2 mm wide.

Two varieties recognized:

6a. var. **bussei**

G. stenophyllum Bak. var. *flavoviride* Uetzsch. & Merxm. in Transact. Rhod. Sc. Ass. 43: 57 (1951). Type: Rhodesia: Marandellas distr., Dehn 7194 (SRGH!).

G. stenophyllum auct., non Bak.

Stems (at least on the angles) and leaves (mainly lower surface) covered with short, ± spreading white hairs.

Habitat: In grassland (often *Themeda*-veld), in open *Brachystegia* woodland; sometimes on rocky outcrops and streamsides. Ca. 1 200–1 800 m.

Flowering Period: October to February (March, April, May).

Distribution (maps, Figs. 16, 17): From Tanzania and Malawi to Rhodesia.

6b. var. **glabrum** Brenan in Mem. N.Y. Bot. Gard. 8: 456 (1954). Type: Tanzania, Mbulu distr., Ufome Mtn., Burr 2728 (EA, K!; NU, WU: photos!).

Stems and leaves without short, ± spreading white hairs, or plants glabrous altogether. Nodes may occasionally be ± hairy.

Habitat and Flowering Period: As in var. *bussei*.

Distribution (maps, Figs. 16, 17): From Tanzania, East Zambia, Malawi and Mozambique to Rhodesia.

Critical Remarks: *G. bussei* has consistently been confused with *G. stenophyllum* Bak., a species not at all closely allied to *G. bussei* but belonging to *Galium* sect. *Aparinoides* (Puff, 1974) and restricted to Tropical Africa. For a discussion and clarification of this problem refer to Brenan (1953).^{11, 12}

On the basis of synflorescence structure, *G. bussei* is subdivided into two groups of varieties (dense, many-flowered: var. *bussei*, var. *glabrum* Brenan; lax, diffuse, sometimes few-flowered: var. *strictius* Brenan, var. *glabrostrictius* Brenan). Only the first group is represented in Rhodesia (the other is restricted to Malawi, Tanzania, Zambia and Zaire), and, at least as far as Rhodesian material is concerned, the further separation into a hairy (var. *bussei*) and glabrous form (var. *glabrum*) appears to be worth following [Verdcourt (1976:400) considers the present subdivision somewhat unreliable, but his investigations were based on tropical material only]. Glabrous and hairy forms may sometimes be found together [cf. Miller 5639 (SRGH), for example].

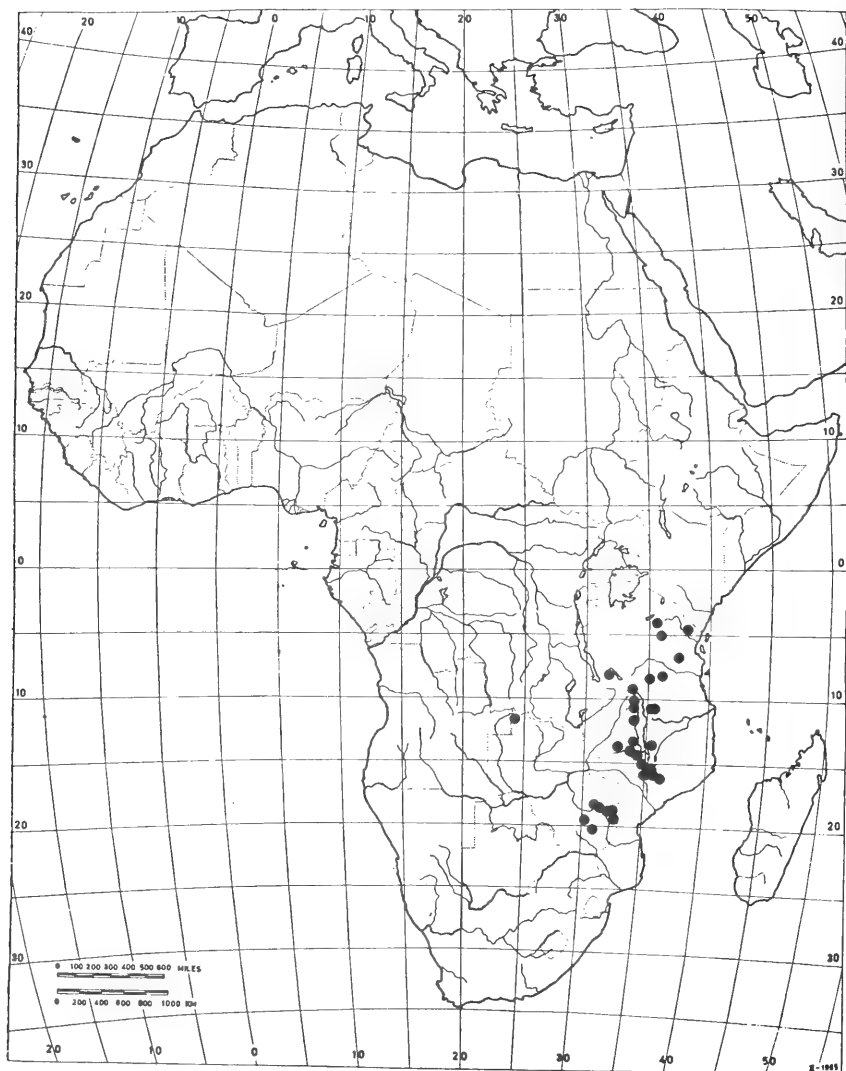


FIG. 16.
Distribution of *G. bussei*
(var. *bussei*, var. *glabrum*, var. *strictius*, and var. *glabrostrictius*).

COLLECTIONS

var. *bussei*

RHODESIA—1731: Ruwa distr., Tanglewood Farm, ca. 1 500 m (-CD), *Miller 5639* (SRGH), 7558 (K, LISC, P, SRGH).

—1831: Marandellas distr., main road near Eagle's Nest, ca. 1 500 m (-BA), *Davies 2969* (SRGH); —, *Dehn 719A* (SRGH).

—1832: Inyanga distr., Inyanga, ca. 1 800 m (-BC), *Boughey 465* (SRGH); —, near village Inyanga Down, *Norlindh & Weimarck 4677* (PRE, SRGH); —, Troutbeck, *Gailey 206* (SRGH); —, way to Slave Pits, *Grosvenor 18* (SRGH); —, Inyanga Falls, ca. 1 600 m, *Jacobsen 3709* (SRGH); Rusape distr., Valhalla (-CA), *Dehn s.n.* sub SRGH 41100 (SRGH); Umtali distr., Watsomba, Kukuransia Irrig. Farm (-DA), *Biegel 1671* (SRGH); —, Umtali Commonage (-DC), *Chase 205* (SRGH).

—1932: Melsetter distr., (-D), *Williams 126* (SRGH).

Uncertain localities Makoni distr., Forest Hill, ca. 1 500 m, *Eyles 723* (SAM, SRGH); —, near Maidstone, *Norlindh & Weimarck 4065* (SRGH).

COLLECTIONS

var. *glabrum*

RHODESIA—1730/1731: Salisbury distr., Chindamore Reserve Gomakarira, ca. 1 500 m, *Wild 3752* (LISC, PRE, SRGH).

—1731: Ruwa distr., Tanglewood Farm, ca. 1 500 m (-CD), *Miller 5639* (SRGH); —, Ruwa, Rockfall Farm, ca. 1 500 m, *Miller 8083* (K, LISC, PRE, SRGH).

—1832: Inyanga distr., near Inyanga (-BC), *Fries Norlindh & Weimarck 2445* (SRGH); —, Juliasdals, Pienaar's Farm, *Rutherford-Smith 507* (SRGH); —, near Darmalsay (?spelling), *Whellan 713* (SRGH); —, *Hopkins 8602* (SRGH); Pungwe Hills distr., (-BD), *Hopkins 7156* (PRE, SRGH); Umtali distr., Christmas Pass (-DC), ca. 1 350 m, *Matineau 296* (SRGH), '*Herb. Q.V.M. 7092*' (SRGH); —, Penhalonga, ca. 1 500 m, *Robinson 1857* (SRGH).

—1832: Umtali distr., Umtali Commonage (-DC), *Wild 461* (PRE).

—1832/1932: Umtali distr., Matika's Kloof, *Chase 1905* (SRGH); — Engwa, 1 600 m, *Exell, Mendonça & Wild 3* (LISC, SRGH).

—1929/1930: Selukwe distr., Waterfall Valley, *Duches 2* (LISC, SRGH); —, *Loveridge 565* (SRGH).

—1930: Selukwe distr., Ferny Creek (-CA), *Biegel 1495* (SRGH).

—1932: Umtali distr., Himalaya Mtn., Dickers Farm (-BD), *Dale SKF411* (SRGH); Melsetter distr., 15 m S of Melsetter, ca. 1 800 m (-DD), *Fisher 1261*

(NU, PRE, SRGH); —, Chimanamani National Park, upper Bundi, west tributary, ca. 1 500 m *Phipps 432* (PRE, SRGH); —, on Haroni R., *Mavi 810* (SRGH); —, ca. 3 m SW of Melsetter, on new Umtali rd., ca. 1 400 m, *Drummond 5030* (SRGH); —, Gilbury, ca. 1 000 m (-D), *Wild 3589* (LISC, SRGH); —, *Williams 126* (SRGH).

—2030: Belingwe distr., Bukwa Mtn., ca. 1 300 m, (-CB), *Pope, Siegel & Simon* ¹⁹⁷⁷ *Mtunumashava Hill* (-BB), *Grosvenor 511* (SRGH).

—2030: Fort Victoria distr., Kyle National Park Game Reserve, near base of Mtunumashava Hill (-BB), *Grosvenor 511* (SRGH).

7. *G. scabrelloides* Puff, sp. nov.

Herba perennis, scandens vel decumbens, caudice parum lignoso; caules (0,3)0,5–1,0(1,2) m longi, (1)1,5–2,5(3) mm diam., tetragoni, pilis albis patentibus plus minusve dense obtectis, internodiis (25)30–65(75) mm longis. Folia et stipulae foliaceae (7)8–10-natis verticillata, basi plus minusve cuneata; lamina linearis usque anguste lineari-lanceolata vel oblanceolata, (12)15–20(22) mm longa, (0,6)0,8–4(5) mm lata, apice mucrone albida, margine reflexa et grosse retrorso-aculeata, ceterum pilis albis patentibus supra et infra obiecta, rarius solum nervi pilis muniti. Synflorescentiae multiflorae; pedunculi 2–3 mm longi, pedicellis 1–2,5(3) mm longis, plus minusve filiformibus, pilis albis obiectis, postfloraliter valde divaricatis. Corolla 1,8–3,5(4) mm diam., rotata, vulgo extus pilis albis (sparse) obiecta, lutea vel ochroleuca vel luteo-viridis vel viridula; lobi 4, plus minusve ovati, acuti. Fructus subglobosus usque leviter reniformis, pilis albis strictis patentibus obiectus, rarissime glaber; cocci (0,7)0,8–1(1,2) mm diam.

Perennial with a somewhat woody rootstock. Stems climbing or decumbent, (0,3)0,5–1,0(1,2) m long, often with \pm many lateral branches; (1)1,5–2,5(3) mm in diam., with white spreading hairs at least on the 4 distinct, often whitish angles. Longest internodes (25)30–65(75) mm. Middle cauline leaves in whorls of (7)8–10, 1-nerved, (12)15–20(22) \times (0,6)0,8–4(5) mm, linear to linear-lanceolate or oblanceolate, with a whitish mucro at the apex and cuneate at the base; both surfaces, or at least midrib with white, \pm straight spreading hairs, the (strongly) reflexed margins with closely set, coarse reversed prickles. Synflorescences broadly to narrowly pyramidal, paracladia many-flowered, ultimate branches with 3–1 tiny, linear to lanceolate bracts; peduncles 2–3 mm, pedicels 1–2,5(3) mm, \pm filiform, hairy, strongly divaricate in fruit. Flowers slightly protandrous, 4-merous; corolla 1,8–3,5(4) mm in diam., rotate, usually somewhat hairy outside, bright yellow, creamy-yellow, greenish-yellow or greenish; lobes much longer than wide, \pm ovate, acute; stamina a little less than half as long as the lobes, filaments \pm filiform, anthers elliptic; styles fused to the middle. Fruits dry, (densely) hairy with straight, white spreading hairs, rarely glabrous; mericarps subglobose to slightly reniform, each (0,7)0,8–1(1,2) mm wide; often only one mericarp developed.

Type: South Africa, Natal, Cathedral Peak Forest Reserve, Catchment 9, ca. 2 000–2 200 m, Puff 760314–1/2 (WU).

Chromosome Number: $n = 11$, $2n = 22$.

Habitat: In forest margin vegetation, dense *Leucosidea* and/or *Buddleia* scrub, amongst bushes along stream banks, in vleis, or (more rarely) in open grassland. Confined to damp or wet, \pm shady locations. Ca. (850)1 300–2 600 m.

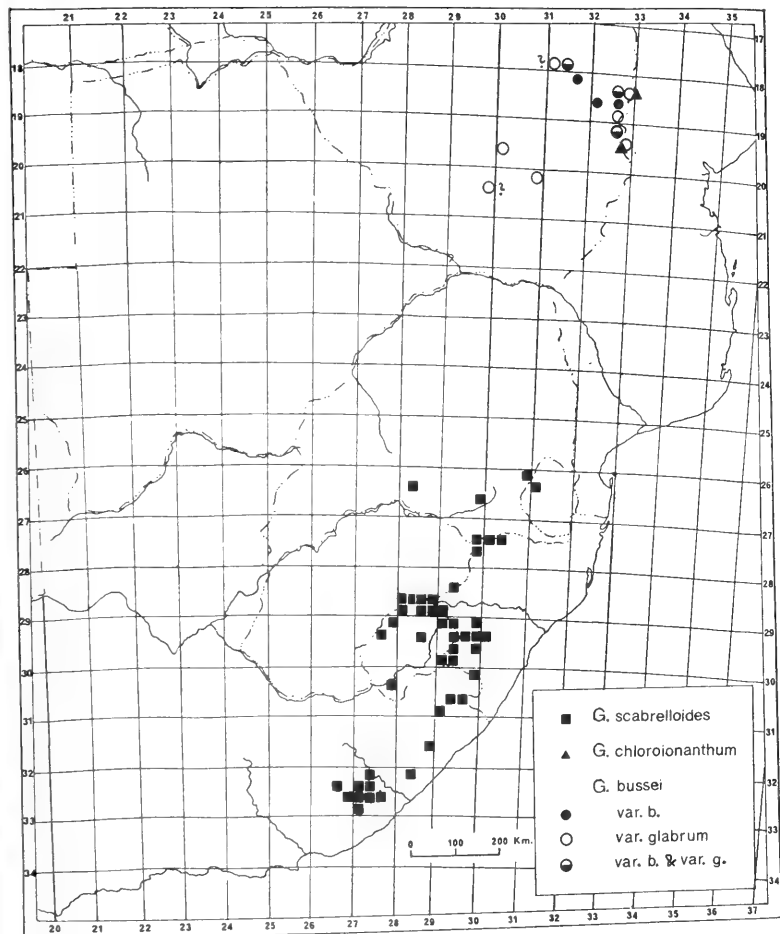


FIG. 17.

Distribution of *G. scabrelloides* (whole range), *G. chloroionanthum* (Southern Africa only), and *G. bussei* var. *bussei* and var. *glabrum* (Southern Africa only).

Flowering Period: December to March.

Distribution (map, Fig. 17): From North West Swaziland through the South East Transvaal, South East Orange Free State, Lesotho, Natal Midlands and Uplands, and Transkei southward to the Eastern Cape Province.

Critical Remarks: *G. scabrelloides* shows close affinity to the \pm tropical East African *G. scabrellum* but differs in having stems with much longer internodes, longer, often broader leaves, frequently very broadly pyramidal synflorescences with bracts at the ultimate branches, longer peduncles and often larger flowers with acute, but not acuminate corolla lobes. Although the two species are sometimes difficult to distinguish morphologically, species status, in my opinion, appears most appropriate for this southern "vicariant" of *G. scabrellum*, particularly in view of the generally narrow species concepts adopted here.

G. scabrelloides displays considerable variability in its growth form (branching pattern) and leaf size and shape, which, to a certain extent, seems to be environment-dependent. Very narrow-leaved, weakish forms were often mistaken for "*G. wittbergense*" (= *G. capense* ssp. *garipense* var. *wittbergense*). They are, however, easily distinguished from the latter by the indumentum (particularly of the gynoecium: straight hairs in *G. scabrelloides*; short, curled hairs in the *G. capense* complex) and the leaf margins with very closely set reversed prickles.

G. scabrelloides and *G. capense* ssp. *garipense* are frequently found growing in the same area, but usually a clear difference in ecological demands is recognizable: *G. scabrelloides* prefers more sheltered, not open habitats and is frequently found in between much higher growing vegetation. It appears to favour somewhat wetter habitats. It was also observed that *G. scabrelloides* begins flowering much later than *G. capense* ssp. *garipense* when the two taxa were seen in the same area. I have seen no hybrids, but in my opinion it cannot be excluded that introgression takes place between the two taxa.

Occasionally one encounters \pm glabrescent forms¹ (subglabrous gynoecium; leaf surfaces with very few hairs only). Since such forms may even occur within populations whose individuals have a perfectly normal indumentum, they of course deserve no taxonomic recognition.

COLLECTIONS

TRANSVAAL—2628 (Johannesburg): Heidelberg Kloof, ca. 1 500 m (-AD), *Story 1613* (PRE: \pm atypical).

—2629 (Bethal): Ermelo (-DB), *Leendertz 7777* (PRE).

—2630 (Carolina): Lochiel (-BB), *Rogers 11478* (PRE).

—2730 (Vryheid): Wakkerstroom, ca. 1 900 m (-AC), *Beeton 232* (SAM); *Kastrolnek* (-AD), *Fitzsimons & Van Dam 26062* (PRE).

¹ Listed as "atypical" in "Collections".

Uncertain locality: Volksrust distr., "Highlands", ca. 1 700 m, *Mogg* 7522 (PRE).

ORANGE FREE STATE—2828 (Bethlehem): Farm "Dunelin" nr. Fouriesburg (-CA), *Potts* 3087 (NBG, PRE); Farm "Dunblane" nr. Clarens (-CB), *Potts* 2984 (PRE); Golden Gate National Park (-DA), *Compton* 22520 (NBG), *Roberts* 3412 (PRE); —, rd. to Generaalskop, ca. 2 700 m, *Roberts* 3114 (PRE; atypical); Witsieshoek (-DB), *Junod* 17508 (PRE); Bester's Vlei nr. Witsieshoek, ca. 1 700 m, *Flanagan* 1935 (SAM, PRE); Bester's valley, ca. 1 900 m, *Bolus* 8170 (BOL); Harrismith distr., *Surit* (?spelling) 115 (PRE). *= Smith?*

Uncertain locality: Vrede distr., Farm "Tygerkloof" ca. 1 700 m, *Pentz* s.n. sub PRE 42022 (PRE).

SWAZILAND—2631 (Mbabane): hill NW of Mbabane, ca. 1 370 m (-AC), *Dlamini* s.n. (K, NBG, PRE). *sub PRE 4198.*

NATAL—2729 (Volksrust): Farm "Glen Atholl" nr. Volksrust and Charles-town, ca. 1 800 m (-BD), *Smith* 5630 (PRE); farm "Boscobello" (-DB), *Jenkins* 25527 (PRE).

—2730 (Vryheid): Groenvlei-Wakkerstroom rd., ca. 3–5 m from Natal/Transvaal border (-AC), *Puff* 770101–3/3 (WU).

—2828 (Bethlehem): Royal Natal National Park, Witsieshoek Gate, ca. 2 200 m (-DD), *Hilliard & Burt* 8593 (E, K, NU); —, Mont-aux-Sources, *Dordge* s.n. (NBG, P, PRE), *Sim* s.n. sub PRE 42019 (NU, PRE); —, Tugela valley, ca. 1 500–1 800 m, *Bayer & Maclean* 48 (K, PRE), *Humbert* 15020 (P). *sub PRE 41980*

—2829 (Harrismith): Van Reenen pass (-AD), *Kuntze* s.n. (K); Umlambonja (= Mhlambonjwa) valley, ca. 1 450 m (-CC), *Schelppe* 7243 (BOL), *Rudatis* 1576 (E, K, S); Cathedral path, ca. 2 450 m, *Schelppe* 107 (NU).

—2929 (Underberg): below Organ Pipes pass, ca. 2 300 m (-AA), *Edwards* 1177 (NU); Giant's Castle Game Reserve, ca. 1 500–1 700 m (-AB), *Trauseld* 538 (NU, PRE), *Coleman* 361 (NH); —, nr. Barnes shelter, *Puff* 761221–1/1 (NU, WU); —, Bushman R. below hutted camp, *Puff* 761221–4/1 (NU, WU); —, tributary of Bushman R. on path to "Main Cave", *Puff* 761221–3/1 (NU, WU); —, Injasuti valley, path to "Battle Cave", *Puff* 760516–2/5 (WU); Cathedral Peak Forest Reserve, Forest Research Station, catchment 3, ca. 1 850 m, *Killick* 1241 (K, NH, S, SRGH); —, catchment 7, *Puff* 760314–8/4 (WU); —, catchment 9, *Puff* 760314–1/2 (WU), –2/2 (WU), –3/1 (NU, WU), –4/1 (NU, WU); —, catchment 10, *Puff* 761120–2/8 (WU); —, nr. Sebaaieni Cave, tributary of Ndedema, *Puff* 761121–3/3 (WU); Giant's Castle, ca. 2 050–2 150 m (-AD), *Symons* 14579 (PRE), *Bruyns-Haylett* 74 (NU); Bushman's pass, ca. 2 200 m, *West* 1667 (PRE); Bushman R. nr. Dalton Bridge (-BB), *Acocks* 10045 (NH); 5 m from jct. of S and N branch of Loteni R., ca. 1 550 m (-BC), *Wright* 1482 (NU); Farm Allandale, adjacent to Kamberg Nature Reserve, ca. 1 950 m, *Puff* 761220–4/1 (NU, WU); summit of Kamberg (-BD), *Puff* 761219–4/1 (NU, WU); above Highmoor Dam, ca. 2 000 m, *Nicholson* 499 (NH); nr. Bushman's Nek police post (-CC), *Hilliard & Burt* 7986

(NU); Drakensberg Gardens, above forester's house, ca. 2 000 m, *Puff* 761226-1/2 (WU); Coleford Nature Reserve, "Sunnyside Cottage" (-CD), *Puff* 761225-1/2 (NU, WU); Mpendhle, ca. 1 520 m (-DB), *Edwards* 2518 (NU); summit of Nhlhosane Mtn. nr. Dargle, *Puff* 761125-3/6 (WU).

—2930 (Pietermaritzburg): Nottingham Road (-AC), *Maclean* 932 (NH).

—3029 (Kokstad): Farm "Lynn Avis", 10 m from Ixopo on Donnybrook rd., ca. 1 300 m (-BB), *Crewe* 51 (NH, NU); Zuurberg nr. Weza, Natal/Transkei border (-DA), *Puff* 760509-1/1 to-1/5 (WU), *Hilliard & Burt* 8054 (K, NU, PRE; atypical), *Schlechter* 6609 (B, BOL, GRA, PRE).

Uncertain or inexact localities: N Berlin Mission station nr. Hoffenthal, *Medley Wood* 3556 (BOL, K, NH, SAM); Mooirivier distr., Warley common, *Mogg* 7183 (PRE); Thackleta (?spelling), *Johnston* 779 (E); Mohlamba (= Drakensberg?) range, ca. 1 500-1 800 m, *Sutherland s.n.* (K).

LESOTHO—2828 (Bethlehem): Leribe, 1 500-1 800 m (-CC), *Dieterlen* 331a (SAM, PRE); Ox Bow Camp, Tschlangana valley, ca. 2 600 m (-DC), *Jacot Guillarmod* 3794 (PRE).

—2927 (Maseru): Mhlatsa's, ca. 2 100 m (-BB), *Jacot Guillarmod* 464 (PRE; atypical); Roma, ca. 1 680 m (-BC), *Ruch* 1742 (PRE), 1940 (PRE), *Schmitz* 337 (PRE).

—2928 (Marakabei): Mountain Road, ca. 2 300 m (-BC), *Jacot Guillarmod* 3321 (RUH, PRE).

—2929 (Underberg): Sani Pass-Mokhotlong rd., base of Black Mtn. (-CB), *Puff* 761209-7/5 (NU, WU).

—3027 (Lady Grey): Liseleng valley (-BD), *Coetzee* 522 (PRE; atypical).

No localities given: "Basutoland", *Cooper* 2499 (K), 2500 (E, Z), *Schmitz* 225 (PRE).

CAPE—3029 (Kokstad): nr. Kokstad, ca. 1 600 m (-CB), *Tyson* 1422 (BOL, PRE), 1626 (SAM, BOL; atypical); nr. Rode, ca. 1 500 m (-CC), *Schlechter* 6434 (B, BOL, PRE).

—3128 (Umtata): nr. Umtata, ca. 900 m (-DB), *Flanagan* 2858 (BOL, PRE).

—3226 (Fort Beaufort): Katberg (-BC), *Sole* 408 (BOL, GRA; atypical), *Schonland* 4290 (GRA; very atypical); Auckland Forest, Amatole Mtns. (-DB), *Lewis Grant* 2777 (BOL, PRE).

—3227 (Stutterheim): Thomas R. (-AB), *Compton* 19296 (NBG; atypical); Happy Valley, "Fenfield" (-AC), *Comins* 1753 (GRA, PRE; atypical); Fort Cunynghame (-AD), *Sim* 2853 (NU); Hogsback (-CA), *Rattray s.n.* sub GRA 420321 (GRA; very atypical); Dohne Hill (-CB), *Sim* 1140 (PRE; atypical); Stutterheim commonage, ca. 700 m, *Acocks* 9771 (PRE; ± atypical); Pirie, ca. 900 m (-CC), *Sim* 196024 (PRE; very atypical); 3 m from Amabele, ca. 800 m (-DA), *Letries* (?spelling) 53 (GRA).

—3228 (Butterworth): Nqamakwe, ca. 900 m (-AB), *Rennie* 399 (GRA; ± atypical).

Inexact or doubtful locations: Inungi Mtns. between Cedarville and Mount Frere, ca. 1 700 m, *Story* 551 (PRE; atypical); "circa Capetown", *De Castelnau* 435 (P; atypical).

8. ***G. scabrellum*** K. Schum. in Bot. Jahrb. **28**: 113 (1899). Type: Malawi, Nyika Plateau, *Whyte* ("Carsson") 269 (B, K!; NU, WU: photos!).

G. bequaertii De Wild. in Rev. Zool. Afr. **9**, Suppl. Bot.: 12 (1921). Type: Zaire, Tshilirunge, *Bequaert* 6047 (BR).

Perennial. Stems scrambling, ca. 450 mm long, \pm much-branched; ca. 1.5–2 mm in diam., with \pm straight, spreading hairs on the 4 distinct angles. Longest internodes 20–25 mm. Middle cauline leaves in whorls of (6–)8(–10), 1-nerved, 10–15 \times (1)1.5–2(2.5) mm, linear to narrowly elliptic, with a distinct, whitish acumen at the apex; upper surface smooth or with a few scattered, \pm straight hairs, lower surface with hairs at least on the midrib, the usually reflexed margins with closely set reversed prickles. Synflorescences \pm cylindrical, paracladia many-flowered, ultimate branches often ebracteate; peduncles 1–2 mm, hairy, pedicels 1–3 mm, hairy or glabrous, divaricate in fruit. Flowers 4-merous; corolla 2–2.5 mm in diam., rotate, often hairy outside, pale yellow; lobes much longer than wide, \pm triangular, acuminate; stamina ca. half as long as the lobes, filaments \pm filiform, anthers \pm elliptic; styles fused to the middle. Fruits dry, glabrous; mericarps \pm globose, each ca. 1 mm wide.

Habitat: Shrubby grassland. Ca. 1 050 m.

Flowering Period: November.

Distribution (maps, Figs. 13, 18): Through the mountain systems of Tropical (East) Africa (Uganda, Tanzania, Zaïre, Rwanda, ? Burundi, Malawi, North East Zambia) extending into Rhodesia.

Critical Remarks: Like *G. chloroionanthum* and *G. bussei*, *G. scabrellum* is a species centred in Tropical East Africa which reaches its Southern limit of distribution in the mountains of East Rhodesia. As already discussed, it is closely related to *G. scabrelloides*, but does not seem to have any other close allies amongst the Southern African *Galia*.

COLLECTIONS

RHODESIA—1832: Umtali distr., Odzani River valley (-DA, -DB), *Teague* 314 (BOL).

9. ***G. subvillosum*** Sond. in Fl. Cap. **3**: 38 (1865). Type: South Africa, Cape Prov., Du Toitskloof, 1 000–2 000 ft., *Drège* 7687 (S!, W!; NU, WU: photos!).

Perennial with a \pm woody rootstock. Stems \pm much-branched, prostrate, ascending or scrambling, 150–500(600) mm long, often purplish; (0.7)1–1.5 mm in diam., with 4 \pm distinct, sometimes whitish angles, hairy with short, spreading

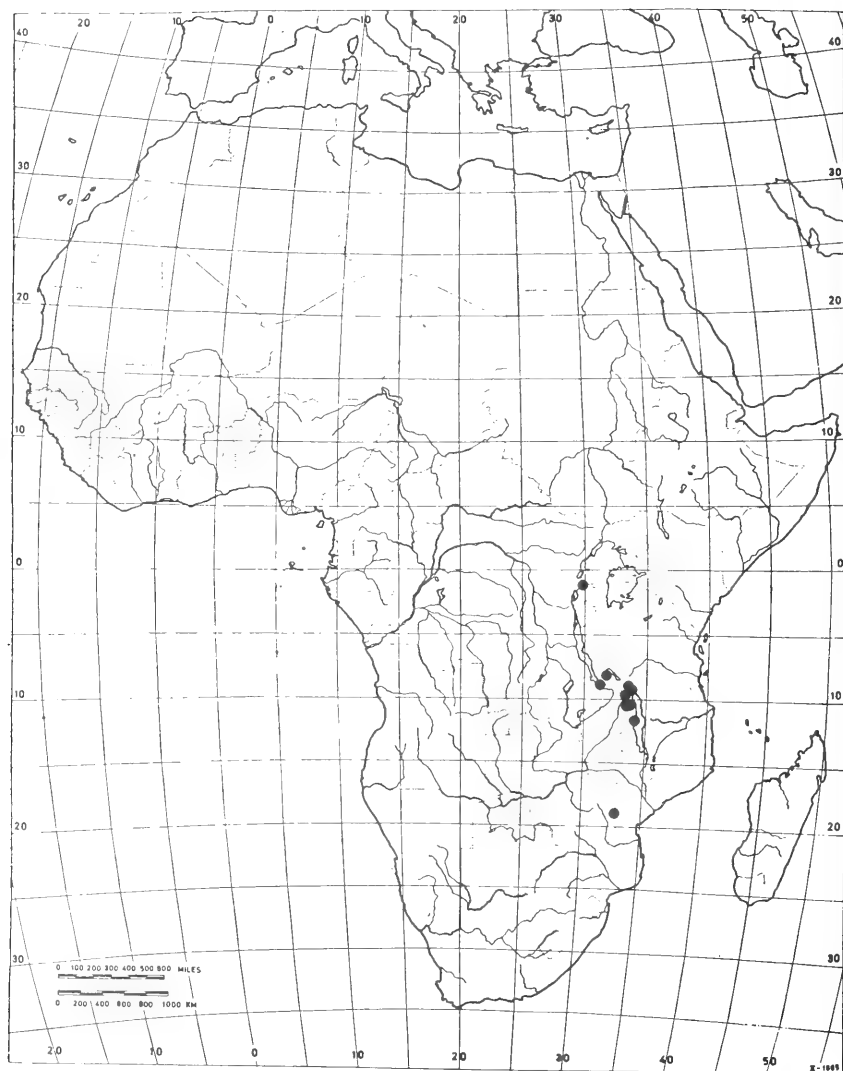


FIG. 18.
Distribution of *G. scabrellum*.

white hairs, glabrous or nearly so. Longest internodes 10–35(40) mm. Middle cauline leaves in whorls of 6, 1-nerved, (5)6–8(11) × (1,5)2–3,5(4,5) mm, oblanceolate or ± lanceolate, with a distinct hyaline point at the apex; with spreading, white hairs on both surfaces and the slightly reflexed margins or glabrous (or nearly so). Synflorescences ± cylindrical, much reduced; paracladia with 3–6 flowers arranged in groups of 3; peduncles (4)5–10 mm, thickish, hairy or glabrous, pedicels with (0)1–2 ± small, lanceolate, hairy or glabrous bracts, (3)4–6(8) mm, slightly elongating after anthesis, thickish to ± filiform, hairy or glabrous, divaricate in fruit. Flowers strongly protandrous, 4-merous; corolla 3–4 mm in diam., rotate, usually a little hairy outside, whitish-yellow, creamy-yellow or purplish; lobes longer than wide, ± ovate, acute; stamina nearly as long as the corolla lobes, filaments ± filiform, anthers small, elliptic; styles ca. $\frac{2}{3}$ fused, less than 1 mm long, free ends arching downward. Fruits dry, wrinkled, with short, straight hairs or glabrous; mericarps subglobose to ± reniform, each 2–2,5(3) mm wide; often only one mericarp developed.

Two varieties recognized:

9a. var. **subvillosum**

Stems and foliage, peduncles and pedicels (densely) covered with short, spreading white hairs. Also corollas (outside) and fruits may be hairy.

Chromosome Number: $n = 22$, $2n = 44$.

Habitat: In grassland, amongst shrubs, at the base of cliffs, on shady river banks; always in fairly moist and cool conditions, never on dry slopes. Ca. (450)600–1 400(1 600) m.

Flowering Period: (August) September to January.

Distribution (map, Fig. 15): Endemic to the mountains of the South West Cape.

9b. var. **subglabrum** Puff, var. nov.

Caules et folia glabra vel pilis albis sparse oblecta, aliter ut in var. *subvillosa*.

Stems and foliage glabrous or nearly so. Also peduncles, pedicels, corolla and fruit are usually hairless.

Type: South Africa, Cape Prov., Bains Kloof, 3 500 ft., *Compton 18632* (NBG).

Chromosome Number: $n = 22$, $2n = 44$.

Habitat and Flowering Period: As in var. *subvillosum*.

Distribution (map, Fig. 15): Endemic to the mountains of the South West Cape.

Critical Remarks: The densely hairy and subglabrous varieties of *G. subvillosum* seem to be worth separating. Both varieties have a similar range of distribution, but var. *subglabrum* appears to be much less common. Although they are sometimes found together [cf. *Puff 760918*–2/1 (NU, WU) and –2/2 (NU,

WU), for example], they, according to my field observations, always remain distinct and were never connected by a series of intermediates.

Veld-burning seems to have little effect on the plants. A comparison of individuals from an unburnt and recently burnt area (carried out at the Jonkershoek State Forest near Stellenbosch) revealed only very insignificant differences: plants from the burnt area showed a somewhat increased vegetative growth, slightly longer internodes and wider leaves, but are inseparable otherwise.

The sometimes purplish colour of stems, flowers, and even leaves appears to come about as a result of overexposure to sunlight. Purplish organs were never observed on plants of \pm shady locations.

COLLECTIONS

var. *subvillosum*

CAPE—3318 (Cape Town): Groot Drakenstein Mtns., S slopes of Banhoek Spitzkop, 1 220 m (-DD), *Esterhuysen 11866* (BOL); Swartboskloof, *Van Rensburg 2107* (PRE); Jonkershoek State Forest, 600–900 m, *Esterhuysen 9709* (BOL, K, PRE), *Puff 760918–2/1* (NU, WU), *Taylor 4612* (PRE), *Rodin 3231* (BOL).

—3319 (Worcester): Ceres (-AD), *Pearson 3522* (B, BOL, K), *Acoks 1879* (S); Slanghoek Mtns., Observation Peak, SE slopes (-CA), *Esterhuysen 1703* (BOL); —, Cossacks, ca. 1 400 m, *Esterhuysen 24008* (BOL); —, Slanghoek, Needle, cliffs on S side, ca. 1 400 m, *Esterhuysen 17796* (BOL, NBG); Du Toitskloof, ca. 300–600 m, *Drège 7687* (S, W), *Puff 760908–6/2* (NU, WU); Witteberg, ca. 1 600 m, *Esterhuysen 15676* (BOL, K, PRE, SAM), *Esterhuysen s.n.* (WU); Bainskloof, ca. 900–1 050 m, *Schlechter 9184* (BOL, E, GRA, K, P, PRE, S, W), *Esterhuysen 25614* (BOL); Franschhoek Forest Reserve (-CC), *Leighton s.n.* sub BOL 31402 (BOL); —, Berg River Hoek, ca. 900 m, *Compton 13817* (NBG); —, near Bushmen's Castle, *Salter 5736* (BOL); Wemmershoek Mtns., Tierkloof, ca. 1 200–1 500 m, *Esterhuysen 17685* (BOL, PRE); Wemmershoek Peak, ledges on W side, ca. 1 200–1 500 m, *Esterhuysen 11331* (BOL, K, NBG); Drakenstein Mtns., Duivel's Kloof, ca. 900 m, *Esterhuysen 1306* (BOL).

—3320 (Montagu): Lemoenshoek Peak, below summit, ca. 1 600 m (-DD), *Esterhuysen 29491* (BOL; \pm atypical).

—3418 (Simonstown): Sir Lowry's Pass (-BB), *Stokoe s.n.* sub SAM 59534 (SAM, PRE); SE of Kogelberg, *Stokoe s.n.* sub SAM 59530 (BOL, SAM; atypical); Pringle E Peak, ca. 600 m (-BD), *Esterhuysen 24660* (BOL; \pm atypical).

—3419 (Caledon): Dwarsberg (-AA), *Stokoe 8646* (BOL, K).

COLLECTIONS

var. *subglabrum*

CAPE—3318 (Cape Town): Jonkershoek State Forest, head of Jonkershoek valley (-DD), *Puff 760918–2/2* (NU, WU).

—3319 (Worcester): Bains Kloof, ca. 1 050 m (-CA), *Compton 18632* (NBG),

Puff 760908-5/11 (NU, WU); Slanghoek Mtns., Witteberg, ca. 1 700 m, *Esterhuysen* 27611 (BOL);—, Slanghoek Pile, ca. 900 m, *Esterhuysen* 1721 (BOL); mountains S of Wemmershoek, S side of summit, 1 450 m (-CC), *Andree* 794 (PRE); Franschhoek Forest Reserve, Berg River Hoek, *Esterhuysen* 12397 (BOL, PRE), *Compton* 13858 (NBG).

—3418 (Simonstown): Sir Lowry's Pass (-BB), *Puff* 760920-2/4 (NU, WU); Somerset Sneeuwkop, ca. 1 200 m, *Esterhuysen* 8273 (BOL, K); Hottentots-Holland Mtns., above Lourens Ford, *Esterhuysen* 3512 (BOL).

—3419 (Caledon): Viljoenspass (-AA), *Puff* 760920-3/1 (NU, WU); SW slopes of Victoria peak, ca. 1 050-1 400 m, *Esterhuysen* 9765 (BOL).

10. ***G. mucroniferum*** Sond. in Fl. Cap. 3: 37 (1865). Types: South Africa, Cape Prov., Du Toitskloof, 1 000-2 000 ft., *Drège* 7677 (E!, K!, WU: photo!); —, near Genadenthal, 2 000-3 000 ft., *Drège* 7686 (E!, K!, P!, PRE!, S!; NU, WU: photos!); no localities given: *Drège* 7684, 7689 (S!); in "Caf-fraria", *Ecklon & Zeyher s.n.* (S!).

G. dregeanum Sond. in Fl. Cap. 3: 38 (1865). Type: South Africa, Cape Prov., Du Toitskloof, *Drège* 7688 (E!, K!, P!, S!; NU, WU: photos!).

Perennial with a ± woody rootstock. Stems with usually many short lateral branches, scrambling, ascending or erect, 100-550 mm long; 1-2(2,5) mm in diam., glabrous, with few reversed prickles or with white, straight spreading hairs on the 4 distinct, often whitish angles. Longest internodes (15)20-45(55) mm. Middle cauline leaves in whorls of 6(-8), 1-nerved, (8)10-14 × (1)1,3-2(2,5) mm, linear-lanceolate to lanceolate, with a long hyaline point at the apex; glabrous or with a few reversed prickles on the slightly reflexed margins, or with white straight, spreading hairs on upper surface, midrib below and margins; often very shiny. Synflorescences often narrowly cylindrical, much reduced; paracladia with 2-4 flowers arranged in groups of 2; peduncles 5-12(15) mm, filiform or ± thickish, glabrous or hairy, pedicels with (3)2-1(0) minute, ± linear, glabrous bracts, (4)6-10(13) mm, elongating after anthesis, ± filiform, glabrous or hairy, strongly divaricate in fruit. Flowers strongly protandrous, 4-merous; corolla (2,5)3-4 mm in diam., rotate, sometimes with a few hairs outside, greenish-yellow, creamy-yellow or pale green; lobes much longer than wide, acute; stamina nearly as long as the corolla lobes, filaments ± filiform, anthers small, elliptic; styles ca. $\frac{2}{3}$ fused, less than 1 mm long. Fruits glabrous, ± granulate or wrinkled, or with short straight hairs; mericarps ± globose, each (2)2,5-3 mm wide; often only one mericarp developed.

Two varieties recognized:

10a. **var. *mucroniferum***

Stems and foliage glabrous or with a few reversed prickles on the angles and margins (but never with white, spreading hairs); peduncles and pedicels never hairy; fruits occasionally with a few hairs.

Chromosome Number: $n = 22$, $2n = 44$.

Habitat: In grassland, rocky slopes and ravines; seems to prefer \pm cool, sheltered and \pm shady locations. Ca. (200)300–900(1 500) m.

Flowering Period: (May to July), September to December.

Distribution (map, Fig. 19): Endemic to the mountains of the South West Cape.

10b. var. **dregeanum** (Sond.) Puff, stat. nov.

G. dregeanum Sond. in Fl. Cap. 3: 38 (1865). Type: South Africa, Cape Prov., Du Toitskloof, Drège 7688 (E!, K!, P!, S!; NU, WU: photos!).

Stems (mainly angles), leaves (margins, upper surface, and midrib on lower surface), peduncles, pedicels and fruits covered with white, straight, spreading hairs.

Habitat and Flowering Period: As in var. *mucroniferum*.

Distribution (map, Fig. 19): Endemic to the mountains of the South West Cape.

Critical Remarks: Varietal status seems most appropriate for *dregeanum*, which differs from *G. mucroniferum* only in its hairiness. The separation character 'more robust' listed by Sonder (1865) only holds for the type specimen (the only specimen known to Sonder), but is by no means consistent.

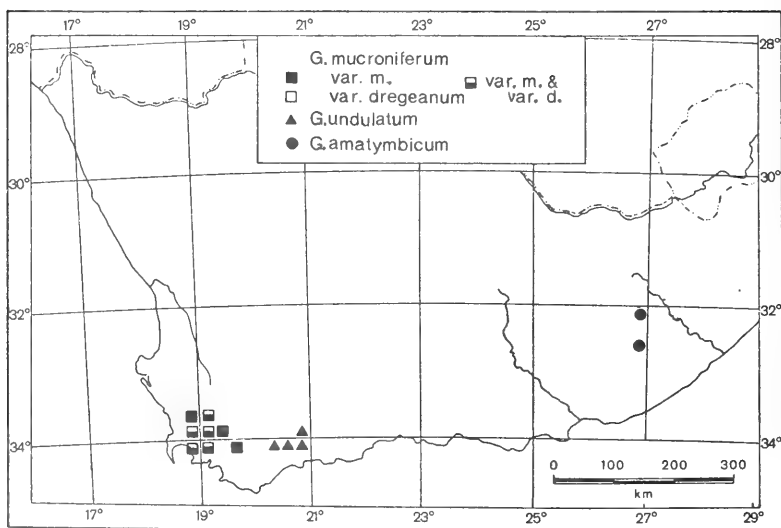


FIG. 19.

Distribution of *G. mucroniferum* var. *mucroniferum* and var. *dregeanum*, *G. undulatum*, and *G. amatymbicum*.

Var. *dregeanum* seems to be much rarer than var. *mucroniferum*.

G. mucroniferum and *G. subvillosum* constitute a very closely related species pair sharing, among others, the following characters: tetraploidy, very pronounced protandry (cf. Fig. 11), flowers with stamina nearly as long as the corolla lobes (long, thin filaments), and reduced synflorescences consisting of few groups of 3 flowers (*G. subvillosum*, Fig. 7c) or 2 flowers (*G. mucroniferum*, Fig. 7d) on the paracladia. All these characters distinguish this group from the remaining Southern African *Galium* species. The two species, however, are, in addition to synflorescence differences, easily kept apart by their leaves (short, wide: *G. subvillosum* vs. long, narrow: *G. mucroniferum*). They may virtually grow side by side in the field [cf. *Puff* 760908-6/2 (NU, WU) and -6/3 (WU)], but, according to my field observations, do not hybridize.

COLLECTIONS

var. *mucroniferum*

CAPE—3318 (Cape Town): Paarl Berg (-BD), no collector given (K); Simonsberge (-DD), *Esterhuysen* 8812 (BOL); Jonkershoek State Forest, *Parker* 4473 (BOL, K, NBG), *Kerfoot* 5863 (PRE); —, Biesievlei, ca. 300 m, *Rycroft* 865 (NBG); —, Abdol's Kloof, ca. 360 m, *Levyns* 7354 (BOL), *Taylor* 4570 (PRE), *Adamson* 3042 (BOL); —, Idasvallei, ca. 180 m, *Levyns* 1418 (BOL).

—3319 (Worcester): Slanghoek Mtns., Witteberg, ca. 1 500 m (-CA), *Esterhuysen* 9465 (BOL); Du Toitskloof (-CA, -CC), *Drège* 7677 (E, K), *Drège* s.n. (K), *Stokoe* s.n. sub SAM 70002 (SAM), *Barker* 5980 (NBG), *Puff* 760908-6/3 (WU); —, above Mountain Club Hut (-CA), *Esterhuysen* 16548 (BOL, PRE), *Taylor* 5416 (PRE); Franschoek pass, ca. 460 m (-CC), *Marsh* 658 (SRGH, K), *Compton* 18564 (NBG); —, ca. 900 m, *Schlechter* 9252 (BOL, E, K, P, PRE, S); Wemmershoek Peak, *Esterhuysen* 11343 (BOL, K); Stettynsberg Mtns. (-CD), *Stokoe* s.n. sub SAM 64217 (SAM).

—3418 (Simonstown): W side of Sir Lowry's Pass, just below top (-BB), *Acocks* 5226 (S); near Hottentots-Hollandskloof, *Ecklon & Zeyher* 2327 (SAM; not P, S).

—3419 (Caledon): Houhoek Mtns., Nieuwkloof (-AA), *Burchell* 8035 (K); Genadenthal, ca. 600-900 m (-BA), *Drège* 7686 (E, K, P, PRE, S).

Uncertain location: "In Caffraria", *Ecklon & Zeyher* s.n. (S).

COLLECTIONS

var. *dregeanum*

CAPE—3318 (Cape Town): Stellenbosch (DD), *Duthie* 577 (BOL); —, Papegaaisberg, *Worsdell* s.n. (K).

—3319 (Worcester): Du Toitskloof (-CA, -CC), *Drège* 7688 (E, K, P, S).

Highly doubtful location: "Port Natal", *Gueinzus* s.n. (W).

11. *G. undulatum* Puff, nom. nov.

G. uncinatum Lichtenst. in Bartl. & Wendl., Beitr. z. Bot. 2: 12 (1825), nom. illeg. Type: South Africa, Cape Prov. ("Cap. b. Spei"), Lichtenstein s.n. (GOET!).

G. glabrum sensu Sond. in Fl. Cap. 3: 38 (1865), non Thunb.

Perennial with a slightly woody rootstock. Stems ascending to erect, ca. 0,3–1,5 m long, usually with few lateral branches; 1,5–2,5 mm in diam., glabrous or with a few reversed prickles on the 4 distinct angles, often \pm glaucous. Longest internodes 30–55(70) mm. Middle cauline leaves in whorls of 6, 1-nerved, (15)20–30 \times (6)8–10(11) mm, obovate to obovate-oblong, with a short hyaline point at the apex, cuneate at the base; margins with \pm coarse reversed prickles, leaves otherwise glabrous; often glaucous. Synflorescences \pm cylindrical, paracladia 3- to \pm many-flowered, ultimate branches usually ebracteate; peduncles (5)10–22 mm, glabrous, pedicels (3)5–10(20) mm, slightly elongating after anthesis, filiform, glabrous, divaricate in fruit. Flowers 4-merous; corolla (2,5)3–4 mm in diam., rotate, whitish; lobes much longer than wide, acute; stamina very short, much less than half as long as the lobes, filaments thickish; styles short. Fruits dry, glabrous, granulate; mericarps \pm globose, each (2)2,5–3,5 mm wide.

Habitat: Among shrubs on river banks, forest margins and mountain slopes. Always in moist to wet, \pm shady locations. Ca. (300)450–1 050(1 200) m.

Flowering Period: September to December (January, February).

Distribution (map, Fig. 19): Endemic to the mountains around Swellendam, Barrydale and Heidelberg.

Critical Remarks: *G. undulatum* has until now been known as "*G. glabrum* Thunb.". After an examination of the type specimen [Thunberg 3315 (UPS)], however, it became evident that "*G. glabrum*" must be considered a synonym of *G. tomentosum* (see *G. tomentosum*, "Critical Remarks").

The name *G. uncinatum* Lichtenst., considered a synonym of "*G. glabrum*" by Sonder (1865), unfortunately is illegitimate: it is a later homonym (4 years) of the validly published name *G. uncinatum* S. F. Gray (1821). The name *G. undulatum* was chosen as nomen novum because this name had already been associated (although erroneously) with *G. uncinatum* Lichtenst. by Steudel (1840), who lists (p. 658) "*G. undulatum* Lichtenst. in Bartl. Wendl. sec. Ecklon" as a synonym of "*G. glabrum* Thunb.". Ecklon's reference to *G. undulatum* Lichtenst. must have been in error for *G. uncinatum*, the only *Galium* described by Lichtenstein.

G. undulatum is undoubtedly very closely allied to *G. tomentosum* with which it shares the following characters: (usually) very wide, oblanceolate or obovate leaves with reversed prickles on the margins (otherwise glabrous), flowers with very short stamina, and large fruits. Of the two, *G. tomentosum* (dioecious, "sex-dimorphism") clearly is the more derived species.

COLLECTIONS

CAPE—3320 (Montagu): Lemoenshoek Peak, slopes above Boesmansbos Forest, ca. 1 050–1 200 m (-DD), *Esterhuysen* 10464 (BOL, K); Grootvadersbosch Forest Reserve, Boesmansbos, ca. 1 050 m, *Taylor* 3223 (PRE).

—3420 (Bredasdorp): Swellendam (-AB), *Cohen s.n.* sub NBG 23401 (NBG), *Kuntze* 30 (K); Swellendam Mtn., *Esterhuysen* 4809 (BOL); Duiwelsbosch near Swellendam, *Cruse* 29 (S); Duiwelsbosch and Voormansbosch near Puspas Valley (-AB?), *Ecklon & Zeyher* 2325 (PRE, S, SAM); on both sides of the Buffeljagdrivier, ca. 300–600 m (-BA), *Zeyher* 2725 (K, P, S, SAM, W); Goede Hoop Farm, mountain slopes, ca. 600 m (-BB), *Thorne s.n.* sub SAM 44517 (SAM).

12. *G. tomentosum* Thunb., Fl. Cap. 1: 551 (1813). Type: South Africa, Cape Prov. ("CBS"), *Thunberg* in herb. Thunberg sub no. 3373 & 3374 (UPS!; NU, WU: photos!).

G. asperum Thunb., Prod. Pl. Cap.: 30 (1794), nom. illeg., Type: South Africa, Cape Prov. ("CBS"), *Thunberg* in herb. Thunberg sub no. 3302 (UPS!; NU, WU: photos!).

G. glabrum Thunb., Fl. Cap. 1: 551 (1813). Type: South Africa, Cape Prov. ("CBS"), *Thunberg* in herb. Thunberg sub no. 3313 (UPS!; K, NU, WU: photos!).

G. asperum var. *villosum* Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 369 (1836). Type: South Africa, Cape Prov., Clanwilliam distr., near Brakfontein, *Ecklon & Zeyher* 2323 β (GOET!, P!, S!; WU: photo!).

G. namaquense Schlechter, nom. nud.

Rubia lanata Dinter, nom. nud.

Dioecious perennial with a woody rootstock. Stems climbing or scrambling, ca. 0,3(0,5)–2,5(3,0) m long, with many lateral branches; up to 15(20) mm in diam. and terete at the base, (1)1,5–3(4) mm in diam. and distinctly 4-angled in the mid-stem region; with reversed prickles on the angles or (rarely) subglabrous, the upper parts of the stems frequently densely villous; greyish at the base, often purplish in the upper parts. Longest internodes (20)30–80(100) mm. Middle cauline leaves in whorls of 6–8, 1-nerved, (12)15–25(30) \times (2)3–8(10) mm, narrowly to broadly obovate, broadly ovate, or \pm lanceolate, often acuminate or acute at the apex and cuneate at the base; with densely set reversed prickles on the often slightly reflexed margins and midrib beneath. Synflorescences extensive, \pm broadly pyramidal, paracladia many-flowered, of rather different appearance in σ and ρ plants. σ : peduncles (1)2–3 mm, \pm thickish, subglabrous to villous, pedicels 1–2 mm, \pm filiform, hairy, strongly divaricate; ρ : peduncles (10)15–30(35) mm, somewhat elongating after pollination, villous; pedicels (20)25–60(90) mm after pollination, \pm thickish, convergent. Flowers 4-merous; σ : corolla (2)2,5–3,5(4) mm in diam., rotate, greenish, greenish-yellow to pale yellow.

occasionally somewhat hairy outside; lobes much longer than wide, \pm ovate, acute; stamina very short, filaments thickish, shorter than the ovate anthers, gynoecium rudimentary, disk small. ♀: corolla 3–4 mm in diam., otherwise as in ♂; styles ca. 1 mm, ca. $\frac{2}{3}$ fused, disk larger than in ♂; rudimentary stamina usually recognizable. Fruits dry, granulate, glabrous or sometimes with a few whitish hairs; mericarps \pm reniform, with 3 distinct furrows along the back, each (1)1,5–2 mm wide and (2)2,5–3 mm long.

Chromosome Number: $n = 22$, $2n = 44$.

Habitat: In semistabilized and stabilized coastal dunes, usually amongst bushes. Inland generally scrambling in \pm dense scrub of dry, sun-exposed slopes or river banks, or in dried out river beds; seems to prefer (semi-)arid areas with an annual rain fall of usually not more than ca. 400 mm. Sea level—600 (900) m.

Flowering Period: (August) September to November (December).

Distribution (map, Fig. 20): From the Southern Namib ["desert and succulent steppe": Giess (1971)] through Namaqualand to the South West Cape; in the Little, Great and Upper Karroo, and eastwards to the Eastern Cape Province.

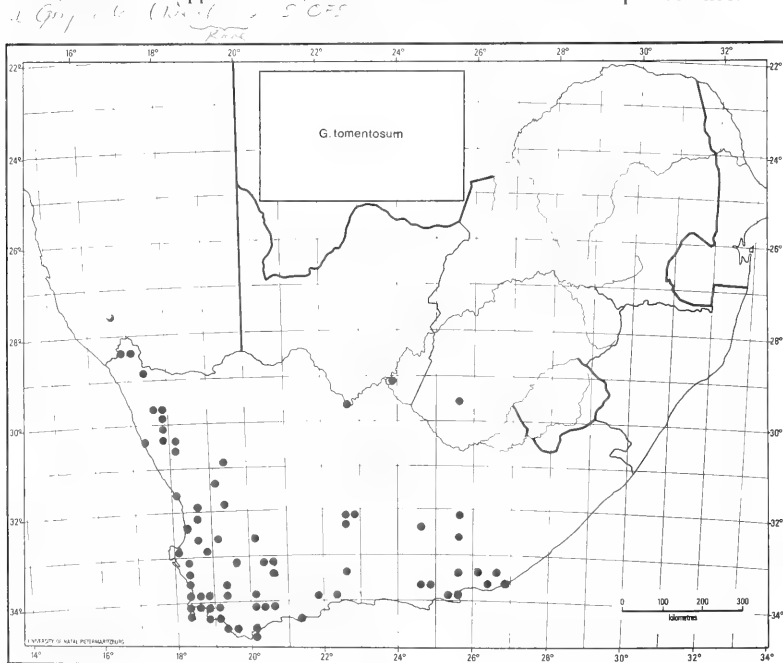


FIG. 20.
Distribution of *G. tomentosum*.

Critical Remarks: *G. tomentosum* and *G. asperum* Thunb. [an illegitimate name: there is an earlier homonym by Schreber (1771)] had long been considered separate species (Ecklon & Zeyher, 1836; Sonder, 1865; Marloth, 1932), since the early authors did not realize that the "two" species are in fact only ♂ (*G. asperum*¹) and ♀ (*G. tomentosum*) plants of a single species (probably because ♂ and ♀ plants look quite different: dioecism coupled with sex-dimorphism, see below). Salter (1937) finally clarified the situation.

G. glabrum Thunb., described on the same page as *G. tomentosum*, should be included as a synonym of the latter: it merely represents a somewhat atypical (subglabrous), but clearly male plant of *G. tomentosum*.

Dioecism has evolved in a number of *Galium* species, but *G. tomentosum* is the only Southern African species to show this phenomenon. It is also one of the very few in which dioecism is coupled with sex-dimorphism (*G. cotinoides* de Cham. & v. Schlechtend., a Chilian species not related to *G. tomentosum*, for example, is another: Ehrendorfer, personal communication). Although the synflorescences of ♂ and ♀ plants have an identical basic structure (cf. Fig. 7a), their appearance is rather different: in ♀ plants the densely villous peduncles and pedicels are much elongated and \pm weak so that in nature they are always pendulous (Fig. 21a, b). In ♂ plants, peduncles and the much less hairy or subglabrous pedicels are short, stiff and straight, and, as a result, the synflorescences are not pendulous. At present, no explanation of the function or possible advantage of dioecism and the long, pendulous ♀ synflorescences in *G. tomentosum* can be offered, but they are certainly not an adaption to anemogamy: *G. tomentosum* is clearly entomogamous, and both, ♂ and ♀ flowers produce much nectar and were frequently found to be visited by small insects particularly in Namaqualand.

No exact data are available about the ratio of ♂ and ♀ plants in a population, but according to my field observations there often seemed to be a slight excess of males, which were normally very easy to spot since they apparently always begin flowering earlier than females. Both predominance of males and their earlier flowering are a common and well documented phenomenon in populations of dioecious flowering plants (cf. Godley, 1964, 1976; Lloyd, 1973).

The woody stems of *G. tomentosum* are very conspicuous and can easily reach a diameter of ca. 15 mm near the base. The wood structure, according to Noel (unpublished personal communication), is somewhat derived: the wood consists of short vessel elements, narrow vascular tracheids and parenchyma. There are however no true libriform fibres or vascular rays. There may well be a correlation between the wood structure, unusual for the Rubiaceae, and the ecology of the species: herbaceous, non-woody genera of various non-rubiaceous families are known to have evolved "(semi-) desert species" with woody stems, whose wood structure is similarly derived (Noel, personal communication).

¹ *G. asperum* var. *villosum* Eckl. & Zeyher, however, refers to ♀ plants.

Plants of very arid habitats often appear to be deciduous: fruiting plants without leaves were rather common amongst the herbarium material investigated, and even in late spring I could observe in the field that numerous plants had already dropped all their leaves with the exception of a few near the tips of the branches.



FIG. 21.

G. tomentosum (♀) in its natural habitat (Namaqualand distr., near Kamieskroon, Puff 768913-1/5). Explanations in the text.

G. tomentosum is very variable: leaf size and shape in particular may vary considerably (cf. Fig. 5a; note variation within one population), but branching pattern and internode lengths also vary to a certain extent. Variation is also noticeable in the synflorescence region: in ♀ plants there is a continuous series from forms with very many-flowered synflorescences (typical) to forms with rather few flowers on the lateral synflorescence branches (atypical; \pm rare); in ♂ plants the extent of the synflorescences hardly varies. The synflorescence in females is always villous, but not so in males: some forms are villous, others only hairy near the tips of the synflorescence branches, and some (rather infrequently) are almost glabrous (such forms have occasionally been confused with *G. undulatum*). None of these variable characters are, however, correlated so that it does not seem appropriate to subdivide the species further.

COLLECTIONS

SOUTH WEST AFRICA—2716 (Witpütz): 10 m S of Witpütz (-DA), *Merxmüller & Giess* 2375 (PRE, WIND); Numiesberg, *Dinter* 8106 (B, BOL, K, PRE, WIND).

ORANGE FREE STATE—2925 (Jagersfontein): Brakfontein (-DA), *Zeyher* 50 (S).

CAPE—2816 (Oranjemund): Koeboes-Grootderm rd., ca. 7-10 m from Koeboes (-BD), *Puff* 760911-1/1 (WU).

—2817 (Vioolsdrif): Koeboes (Kuboos) (-AC), *Pillans* 5402 (BOL); Stinkfontein (-CD), *Pearson* 5527 (B).

—2917 (Springbok): Springbok-Kleinsee rd., ca. 1 m from turn-off to Komaggas, nr. Buffelsrivier (-DA), *Puff* 760912-1/1 (NU, WU); Spektakelbergpas, ca. 8 m from Springbok, *Puff* 760912-6/4 (NU, WU); nr. Spektakel, ca. 250 m, *Bolus* 9420 (BOL); hills at Okiep (-DB), *Pillans* 4971 (BOL); between Nababiep and Modderfontein, ca. 900 m, *Bolus* 9419 (BOL); hills on W side of Springbok, ca. 980 m, *Acocks* 16488 (PRE); ca. 5 m from Springbok on Pofadder rd., *Puff* 760910-2/1 (NU, WU); Hester Malan Flower Reserve nr. Springbok, *Puff* 760910-1/1 (NU, WU); Droedap (-DD), *Esterhuysen* s.n. sub PRE 41998 (PRE).

—2918 (Gamoep): Brak R., ca. 500 m (-A, -C), *Pearson* 3899 (B, BOL).

—2922 (Prieska): around Prieska (-DA), *Bryant* 227 (K, PRE).

—2923 (Douglas): St. Clair, banks of Vaal R. (-BB), *Orpen* 5967 (BOL); St. Clair-Douglas, *Orpen* 163 (SAM).

—3017 (Hondeklipbaai): margin of dry Spoeg R. bed (-AD), *Pillans* 18034 (BOL); Ara Koop, ca. 700 m (-BB), *Schlechter* 11236 (B, E, GRA, K, S, W); Kamieskroon, *Thorne* s.n. sub SAM 48889 (SAM), sub NBG 23394 (NBG); nr. Kamieskroon, on rd. to Leliefontein, *Puff* 760913-1/5 (NU, WU); Bowesdorp, *Stokoe* 8214 (BOL, PRE, SAM); S of Brakdam (-BD), *Pearson* 5627 (B, BOL, K).

—3018 (Kamiesberg): 3 m E of Kamieskroon, W slopes of Kamiesberg, ca. 1 100 m (-AC), *Acocks* 14988 (PRE); nr. Garies, foothills of Kamiesbergen (-CA), *Esterhuysen* 1409 (NBG, PRE); Wolfhok-Garies rd., ca. 5 m from Garies, *Puff* 760913-2/12 (NU, WU).

—3019 (Loeriesfontein): Loeriesfontein Ravine, ca. 800 m (-CD), *Pearson* 4843 (BOL, K).

—3118 (Vanhynsdorp): Ebenazar, on the Olifants R., below 300 m (-CA), *Drège* 7671 (K, W); Nardouw (-DC), *Maguire* 1048 (BOL, NBG).

—3119 (Calvinia): Bokkeveld, Nieuwoudtville, 700 m (-AC), *Marloth* 7802 (PRE); Botterkloof pass (-CD), *Hall* 3879 (NBG).

—3218 (Clanwilliam): Verlorevlei (-AD), *Compton* 15064 (NBG); Graafwater (-BA), *Zinn* 64219 (SAM); nr. Piketberg (-DA, -DD), *Bolus* 14284 (NH), *Gulline* 2617 (NBG); nr. Brakfontein, *Ecklon & Zeyher* 2323 β (GOET, P, S, WU), *Drège* "76.1" (GOET).

- 3219 (Wuppertal): between Citrusdal and The Baths (-CA), *Puff* 760913-1/1 (NU, WU).
- 3220 (Sutherland): Houthoek (-CA), *Hanekom* 745 (PRE).
- 3222 (Beaufort West): Nieuwefeld (-BA), *Drège s.n.* (S); between Beaufort and Renosterkop, ca. 760–910 m (-BB, -BC), *Drège s.n.* (K); Sunnyside (Beaufort West distr.), *Esterhuysen* 2729 (PRE).
- 3224 (Graaff-Reinet): nr. Graaf-Reinet, ca. 760 m (-BC), *Bolus* 144 (BOL, K), 145 (BOL).
- 3225 (Somerset East): Baroda, 15 m N of Cradock, ca. 950 m (-BA), *Dyer* 1044a (GRA, PRE); Somerset East (-DA), *Bowker s.n.* (K); Somerset East distr. (?): between Zuurbergen and Klein-Bruitjeshoogte, *Drège s.n.* ("tomentosum a", E, K, P, S, W).
- 3318 (Cape Town): In fields nr. Hopefield (-AB), *Letty* 134 (PRE); Darling, ca. 75 m (-AD), *Gulline* 2104 (NBG); nr. Darling, ca. 110 m, *Bolus* 12702 (BOL, NH, PRE), *Puff* 760915-1/1 (NU, WU); Groot Post, *Salter* 6471 (BOL); Contreberg, *Bachmann* 1100 (K, P); around Mamre ("Groenekloof") (-CB), *Zeyher s.n.* sub SAM 10675, 37551 (SAM); Mamre Hill, *Compton* 9829 (NBG); Blaauwberg (Blouberg), *Stokoe* 67538 (SAM); Blaauwbergstrand (-CD), *Maguire* 1279 (NBG); Milnerton (-CD, -DC), *Andrae* 389, 392 (PRE); Harmonie (-DC), *Michell* 238 (BOL, PRE); mountainous places at Klappmuts, ca. 150–460 m (-DD), *Ecklon & Zeyher s.n.* sub PRE 20106 (PRE; as "Drège 92.10" in GOET, WU).
- 3319 (Worcester): nr. Karroo Poort, Swartuggens Mtns. (-BA), *Stokoe* 7537 (SAM); "Veld Reserve" nr. Worcester (-CB), *Olivier* 152 (PRE), *Van Breda* 36 (PRE); Hex River nr. De Doorn, ca. 500 m (-CD), *Bolus* 11899 (PRE); entrance to Hex R. valley, *Davidson* 45 (SAM).
- 3320 (Montagu): Snyders Kloof (-AB), *Foley* 139 (PRE); Matjiesfontein, ca. 900 m (-BA), *Compton* 2715 (BOL); —, ("Maggiesfontein"), *Rehmann* 2939 (K); environment of Matjiesfontein, Witteberg at Whitehil, *Humbert* 9750 (P); foot of Witteberg (-A, -B), *Compton* 2528 (BOL); Witteberg Kloof, *Adamson s.n.* (BOL); Ngaap Kop, ca. 1 070 m, *Compton* 12620 (NBG); Dobbelaars Kloof, ca. 700 m (-BC), *Levyms* 6663 (BOL; atypical); Montagu baths (-CC), *Page s.n.* sub PRE 42011 (PRE); Baden Kloof, ca. 500 m (-CC?), *Compton* 18364 (NBG), *Lewis s.n.* sub SAM 59532 (SAM), *Levyms* 7941 (BOL); Kochmannskloof (Kogmans Kloof) (-CC), *Zeyher s.n.* (SAM).
- 3321 (Ladismith): Bergkloof, ca. 7 m from Herbertsdale (-DD), *Puff* 760922-1/1 (NU, WU).
- 3322 (Oudtshoorn): De Rust, Farm "Doornkraal", 400 m (-BC), *Dahlstrand* 1575 (GRA), 2183 (PRE), 2454 (PRE); George (-CD), *Ecklon & Zeyher* "94.12" (S.).
- 3323 (Willowmore): Willowmore distr., Wolvefontein, *Anderson s.n.* sub SAM 3755 (SAM).

- 3324 (Steytlerville): Kouga R. Poort, ca. 300 m (-DA), *Fourcade* 3083 (BOL, K); on the Zwartkoprivier (-DB), *Zeyher* 225 (K, S, SAM), 2720 (S).
- 3325 (Port Elizabeth): Dunbrodie, Sundays R. valley, ca. 60–120 m (-BC), *Rennie* 406 (BOL; atypical); Uitenhage (-CD), *Ecklon & Zeyher* '2-1' (S); Redhouse (-DC), *Paterson* 96 (GRA), 96a (GRA, BOL); Uitenhage-Coega rd., ca. 1.3 m from Coega, *Puff* 760924-1/1 (NU, WU).
- 3326 (Grahamstown): Alicedale (-AC), *Cruden* 66 (GRA); Cradock rd., 6–7 m outside Grahamstown (-BC), *Stauffer* 5191 (K, P, PRE), 5192 (P, PRE); Alexandria-Pt. Alfred rd., ca. 5 m from Alexandria (-CB), *Puff* 760924-2/1 (WU); Pt. Alfred (-DB), *Marloth* 10201 (PRE); Albany distr., Albany, *Bowker* s.n. (K).
- 3418 (Simonstown): Rondevlei (-AB), *Compton* 24362 (NBG); nr. Muizenberg, 6 m, *Schlechter* 1487 (B); Fish Hoek Bay, ca. 15 m, *Bolus* 4834 (BOL); Kommetjie, *Brain* s.n. (SRGH); Witsand Bay, *Salter* 6386 A, B, C (BOL, K, S); Southeast Point, *Wolley Dod* 2991 (K); Cape of Good Hope Nature Reserve, nr. Cape of Good Hope (-AD), *Puff* 760917-1/1 (WU); Swartklip (-BA), *Puff* 760919-2/14 (NU, WU), *Esterhuysen* 26456 (BOL); nr. Zeekoe Vlei (-BA, -BB), *Wolley Dod* 872 (BOL); Faure (-BB), *Parker* 4509 (BOL, K, NBG); Hottentots-Holland Mtns., *Zeyher* s.n. (S), *Liuvemberg* (?spelling) s.n. (S), no collector given (K); surroundings of Somerset West, in Hottentotsholland, *Ecklon & Zeyher* '83' (S); E of Cape Hangklip (-BD), *Rourke* 704 (NBG, S).
- 3419 (Caledon): Bosjesveld (-AA), *Van Zijl* s.n. (SAM); Friekkie be Saai (-AC), *Leighton* 1556 (BOL), E of Betty's Bay, *Puff* 760920-1/1 (NU, WU); between Elim and Gansbaai (-CB, -DA), *Stokoe* s.n. sub SAM 64218 (SAM).
- 3420 (Bredasdorp): ca. 1.5 m outside Stormsvlei on Stormsvlei-Bonnievale rd. (-AA), *Puff* 760921-1/1 (NU, WU); Swellendam (-AB), *Ecklon & Zeyher* '98-9' (S); nr. Swellendam, *Zeyher* s.n. sub SAM 16075 (SAM); nr. Bontebok (-AB, -BA), *Wall* s.n. (S); Struis Bay (-CA, -CC), *Esterhuysen* 4433 (BOL), *Hafström & Acocks* 2242 (PRE, S).
- 3421 (Riversdale): Stilbaai (-AD), *Muir* 120 (GRA), 5101 (BOL, PRE).
- Uncertain or doubtful localities: Little Namaqualand, Waterkloof at Doornpoort, *Pillans* 5370 (BOL); "Stellenbosch, Worcester, Swellendam and Uitenhage", *Ecklon & Zeyher* 2323 (GOET, P, S, SAM, W); "Karoo", *Ecklon & Zeyher* 2324 (GOET, P, S, SAM, W); "Vumansberg" (?spelling), *Julinek* s.n. (W); "Regio orientalis" or "CBS", *Sparman* s.n. (S), *Thunberg* s.n. (S, 4 sheets), *Wolley Dod* 3680 (BOL), *Drège* s.n. (K), *Zeyher* s.n. (K), *Zeyher* herb. no. 347 (P), *Dahl* s.n. (S), *Bauer* 94 (W), *Scholl* s.n. (W).

13. *G. chloroionanthum* K. Schum. in Bot. Jahrb. 30: 417 (1901). Type:

Tanzania, Rungwe Mtn., *Goetze* 1162 (B, BM, K!; NU, WU: photos!).

Perennial. Stems climbing or creeping, up to 2.3 m long, with few lateral branches; 1.5–2 mm in diam. (mid-stem), with \pm large, hyaline reversed prickles on the 4 distinct, whitish angles, and often densely hairy at the nodes. Longest

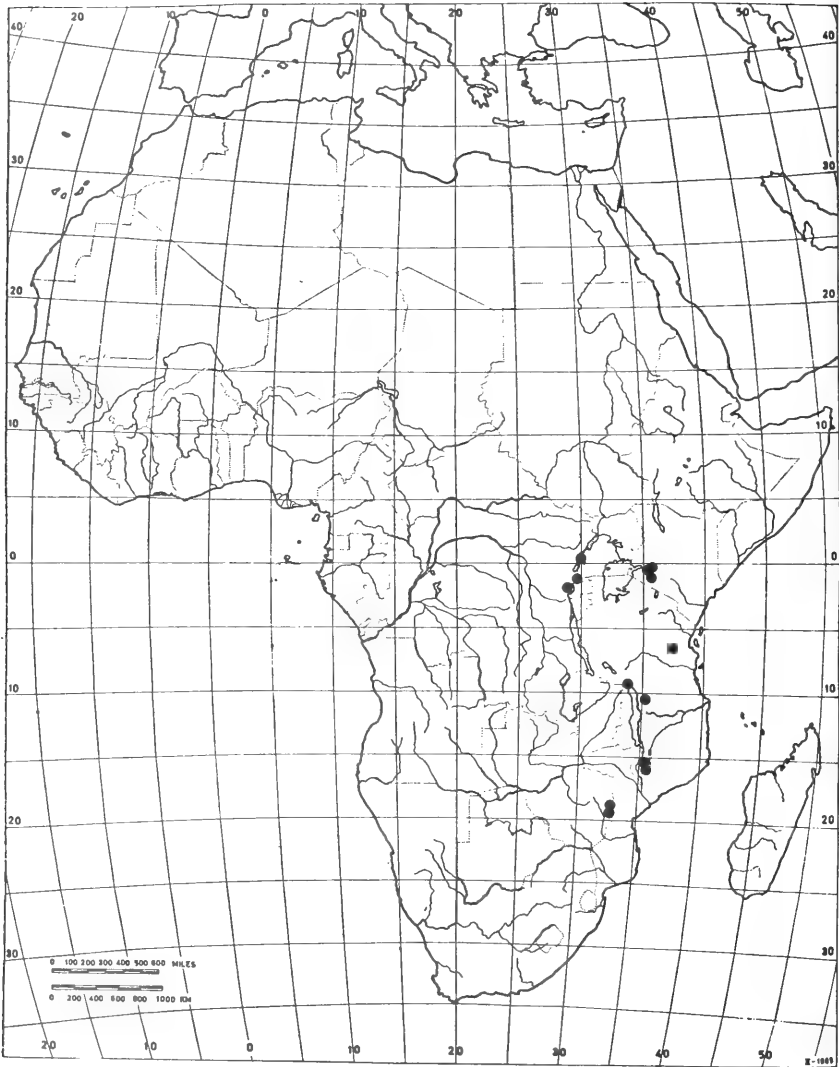


FIG. 22.
Distribution of *G. chloroionanthum*.

internodes 55–100 mm. Middle cauline leaves in whorls of 6, 1-nerved, (22)25–35(40) × (5)7–12(15) mm, (broadly) elliptic to obovate, abruptly acuminate at the apex, cuneate at the base; upper surface glabrous or with a few short, straight hairs, margins and midrib (beneath) with coarse, ± hyaline reversed prickles. Synflorescences extremely reduced; paracladia 1-flowered, peduncles 0.4–0.8 mm before, 10–20 mm after anthesis, pedicels 0.5–1 mm, with 1(2) ± large to minute bract(s), glabrous. Flowers 4-merous; corolla ca. 3–4 mm in diam., rotate, with a few hairs outside, greenish-white to greenish-yellow; lobes about as long as wide, ± acute; stamina short. Fruits dry, densely covered with brownish, flattened (?), hooked hairs; mericarps ± reniform, each 1–1.5 mm wide.

Habitat: In forests. Ca. 1 800–2 000 m.

Flowering Period: December to February.

Distribution (maps, Figs. 17, 22): In tropical East Africa from South Sudan (according to Ehrendorfer & Verdcourt, 1973, and Verdcourt, 1976; no specimens seen by me and, therefore, not shown in map, Fig. 22), Uganda, East Zaïre, Rwanda, Burundi, Kenya to Tanzania, and southward to South Malawi and Rhodesia.

Critical Remarks: The closest allies of the ± tropical *G. chloroionanthum*, which just reaches its southern limit of distribution in the mountains of East Rhodesia, seem to be *G. brenanii* Ehrend. & Verdc., *G. ruwenzoriense* (Cortesi) Chiov., and *G. aparinoides* Forssk., all of which are centred in Uganda, Kenya and Tanzania (Ehrendorfer & Verdcourt, 1973). It does not seem to have close affinities to any Southern African species.

COLLECTIONS

RHODESIA—1832: Inyanga distr., Rhodes Inyanga National Park, Pungwe Gorge, ca. 1 800 m (-BD), *Chase 5664* (LISC, PRE, SRGH).

—1932: Umtali distr., Himalaya Mtn., Banti North, ca. 2 000 m (-BD), *Wild 4517* (LISC, K, SRGH).

14. *G. spurium* L. ssp. *africanum* Verdc. in Kew Bull. **30**: 324 (1975). Type: Kenya, Kiambu distr., Muguga, *Milne-Redhead & Taylor 7147* (K!; NU, WU: photos!).

G. horridum sensu Eckl. & Zeyh.: Enum. Pl. Afr. Austr.: 370 (1836), non Thunb.

G. aparine sensu Sond. in Fl. Cap. **3**: 38 (1865), non L.

Annual. Stems weak, prostrate to semi-erect, (0,12)0,3–ca.2 m long, with ± few lateral branches; (0,8)1,5–2,5 mm in diam., with reversed prickles on the 4 distinct angles. Longest internodes (20)35–75 mm. Middle cauline leaves in whorls of 6–8, 1-nerved, (8)15–38(45) × (1,5)3–6(7) mm, linear-lanceolate to obovate, with a distinct, ± filiform acumen at the apex, cuneate at the base; upper

surface glabrous or with a few scattered \pm straight or curled hairs, midrib (beneath) and margins with coarse reversed prickles. Synflorescences extremely reduced; paracladia 1(2)-flowered, peduncles/pedicels (8)12–20(35) mm when in fruit, \pm arcuate, with reversed prickles or (seldom) glabrous; pedicels occasionally separated from peduncle by a small, \pm linear bract (in that case paracladia often 2-flowered). Flowers 4-merous; corolla (1)1,2–1,8(2) mm in diam., rotate, glabrous, greenish, greenish-white or creamy-white; lobes longer than wide, \pm ovate to triangular, pointed; stamens very short, filaments \pm thickish, anthers roundish; styles short. Fruits dry, with non-tuberculate, white hooked hairs less than 0,5 mm long; mericarps \pm globose, each (1,8)2,5–4 mm wide.

Chromosome Number: $n = 20$, $2n = 40$.

Habitat: Amongst shrubs along river banks, in forest margin vegetation, scrub forests, rocky mountain slopes, or (seldom) in dune forest margins; occasionally in cultivated ground, disturbed areas and margins of plantations. Seems to prefer sheltered, damp and \pm shady locations. Ca. 20–1950 m.

Flowering Period: All year round.

Distribution (maps, Figs. 23, 24): From Ethiopia (Cufodontis, 1965, as *G. aparinoides* Forssk.), Somali Republic, Socotra (not shown in map, Fig. 23), East and West Sudan, Zaïre, Cameroun: Cameroun Mtn., Uganda, Kenya, Rwanda, Burundi, Tanzania and Malawi to South Africa. According to Verdcourt (1976) also in Rhodesia (no specimens seen by me and, therefore, not shown in map, fig. 23).

Critical Remarks: The identity of the plant long identified as *G. aparine* L. in Southern (and Eastern) Africa and often thought to be an introduction from Europe (Sonder, 1865; Adamson & Salter, 1950) is now firmly established: it must be included in *G. spurium* L. as proposed by Verdcourt (1975), and is best treated as a subspecies of its own. One of the main reasons for this conclusion is the plant's chromosome number: *G. spurium* L. has a chromosome base number of $x = 10$ (ssp. *spurium* is diploid and has $n = 10$, ssp. *africanum* is tetraploid and has $n = 20$), whereas *G. aparine* L. has a base number of $x = 11$ (cf. Puff, 1977).

While plants from the Transvaal and Natal always agree perfectly well with the description and type of *G. spurium* ssp. *africanum*, the situation seems somewhat more problematical in the Cape Province: in addition to "typical" collections, there are a number of specimens that differ in having somewhat more extensive synflorescences (\pm long paracladia with three to four, and even six flowers). Such forms bear a close morphological resemblance to both *G. spurium* ssp. *spurium* and *G. aparine*. One is tempted to conclude that they are introductions which, in the Cape Province, occur together with the indigenous *G. spurium* ssp. *africanum*. No chromosome counts of these critical (and rare) plants are available, and, unfortunately, pollen measurements (Fig. 3d) do not contribute much to the solution of the problem either: average pollen diameters are somewhat smaller than those of *G. spurium* ssp. *africanum*, but yet there is a certain amount

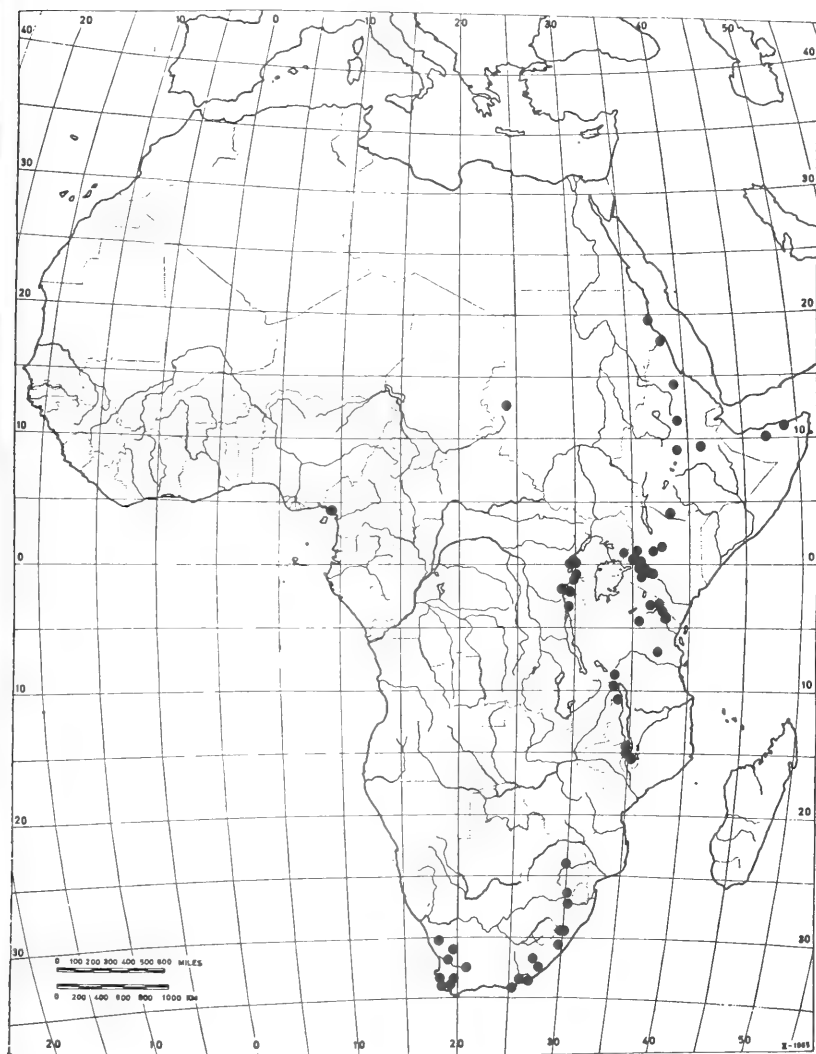


FIG. 23.
Distribution of *G. spurium* ssp. *africanum*.

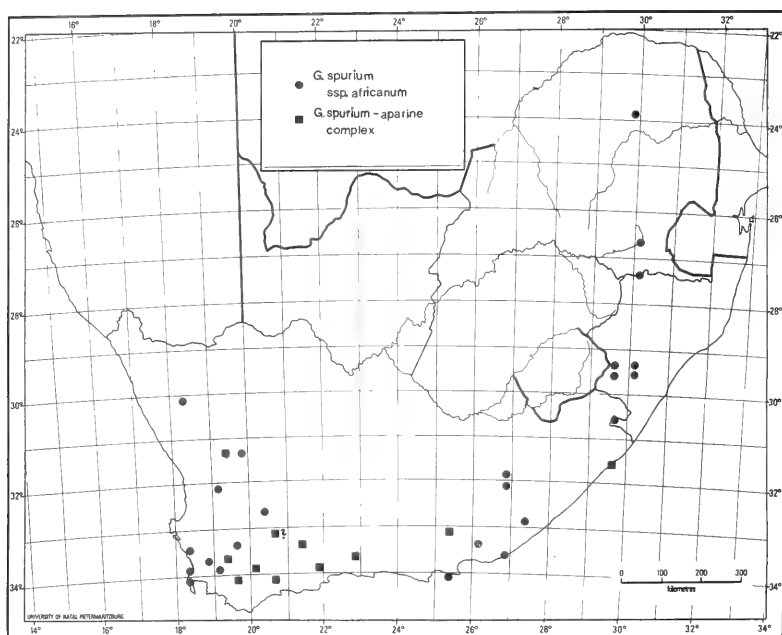


FIG. 24.

Distribution of *G. spurium* ssp. *africanum* in Southern Africa; distribution of plants belonging to the "*G. spurium-aparine* complex" (explanations in the text).

of overlap. Pollen grain size would fit into the range given for the diploid *G. spurium* ssp. *spurium* (cf. Moore, 1975), but on the other hand, the collections in my opinion more closely resemble *G. aparine*, which, however, is polyploid.

A detailed study (which must include karyological investigations), is therefore needed to solve the problem. These critical collections at present can only provisionally be identified as "*G. spurium-aparine* complex".

COLLECTIONS

TRANSVAAL—2329 (Pietersburg): Houtbosh (-DD), *Rehmann* 6031 (K).

—2630 (Carolina): Maviristad (-CA), *Pott* 4886 (BOL), 15152 (PRE).

—2730 (Vryheid): Farm "Oshoek" nr. Wakkerstroom, ca. 1 900 m (-AC), *Devenish* 807 (PRE), *Puff* 770102-3/1 (NU, WU).

NATAL—2929 (Underberg): Kamberg Nature Reserve, Gladstone's Nose ridge, ca. 1 830 m (-BC), *Wright* 837 (NU), *Puff* 760418-1/6 (NU, WU); Farm "Game Pass", Gladstone's Nose Ridge, adjacent to Kamberg Nature Reserve, ca.

1 980 m, *Puff 760418-1/1* (NU, WU), *-1/3* (NU, WU); Bulwer-Impendhle rd., on Ngelotsontwana stream (-DA), *Hilliard & Burt 7610* (E, K, NU); Polela, ca. 1 200–1 500 m, *Medley Wood 4585* (K, NH).

—2930 (Pietermaritzburg): Curry's Post (-AC), *Pickworth s.n.* (NU); Lion River-Dargle rd., roadside nr. Dargle (-CA), *Puff 761125-1/1* (WU).

—3029 (Kokstad): Zuurberg nr. Weza, ca. 1 300 m (-DA), *Schlechter 6604* (B, BOL, PRE).

CAPE—3018 (Kamiesberg): Leliefontein, ca. 1 550 m (-AB), *Levyns 4066* (BOL).

—3119 (Calvinia): nr. Calvinia, on rd. to Clanwilliam, ca. 900 m (-BD), *Levyns 5070* (BOL); Calvinia distr., Ekerdam, *Taylor 2689* (NBG).

—3126 (Queenstown): Queenstown, ca. 1 900 m (-DD), *Galpin 1800* (GRA).

—3219 (Wuppertal): Agtertuin, ca. 240 m (-AA), *Schlechter 10862* (E, GRA, K, P, PRE, S, W).

—3220 (Sutherland): Klipbanksrivier, Roggeveld foothills, ca. 900 m (-CB), *Acocks 16950* (PRE).

—3226 (Fort Beaufort): jct. Queenstown valley and Zwartkei, ca. 1 200–1 350 m (-BB), *Galpin 8125* (PRE).

—3227 (Stutterheim): King William's Town, ca. 600 m (-CD), *Sim 19606* (PRE, WU).

—3228 (Butterworth): Idutywa distr., *Pegler 734* (PRE).

—3318 (Cape Town): summit of Contreberg (-AD), *Pillans 6908* (BOL); Kirstenbosch, Nursery Gorge, Table Mtn. (-CD), *Esterhuysen 352* (BOL); Paarlberg (-DB), *Drège 7670* (E, K, P, PRE).

—3319 (Worcester): Hex River Mtns., E slopes of Prospect Peak, ca. 900 m (-BC), *Esterhuysen 15937* (BOL, PRE); Klein Drakenstein Mtns., Kasteelkloof Catchment, ca. 680 m, *Kruger 1450* (PRE).

—3326 (Grahamstown): Alicedale (-AC), *Cruden 67* (GRA); Port Alfred (Kowie East) (-DB), *Britten 764* (GRA, PRE), *Dyson s.n.*, Nov. 1915 (PRE), June 1916, *Dyson 89* (GRA).

—3418 (Simonstown): Orange Kloof (-AB), *Salter 7822* (BOL); Hout Bay Golf Course, *Acocks 676* (PRE); Simon's Bay, *Wright s.n.* (K).

—3424 (Skoenmanskop): nr. Sea View, margin of dune forest, ca. 60 m, *Acocks 21429* (PRE).

Inexact locality: Namaqualand distr., between Kamieskroon and Leliefontein, ca. 820 m, *Salter 1500* (BOL, K, PRE).

COLLECTIONS

"*Galium spurium-aporine* complex"

CAPE—3119 (Calvinia): Soetwater, 21 m W of Calvinia (-AD), *Maguire 1927* (NBG).

- 3129 (Port St Johns): Port St Johns, ca. 5 m (-DA), *Schonland 4064* (PRE).
 —3319 (Worcester): Worcester, Karoo Garden (-CB), *Barker 5916* (NBG);—, Veld reserve, *Van Breda 55* (PRE), *Olivier 152(a)* (PRE).
 —3320 (Montague): Klein Roggeveld, 1 100 m (-BA?), *Marloth 9600* (PRE); Bonnievale, ca. 500 m (-CC), *Levy's 4585* (BOL).
 —3321 (Ladismith): Seven Weeks Poort, ca. 550 m (-AD), *Levy's 2507* (BOL); Hassaquaskloof (= ? Attaquaskloof) (-DD), *Zeyher 2722* (S, SAM).
 —3322 (Oudtshoorn): Wilge R., WSW of Uniondale, ca. 600 m (-DB), *Acocks 20619* (PRE).
 —3325 (Port Elizabeth): Hoeksplaas, ca. 1 850 m (-AB), *Acocks 23532* (PRE).
 —3419 (Caledon): on the banks of the Zonder-Einde (Riviersonderend) (-BA), *Zeyher 2723* (SAM).
 —3420 (Bredasdorp): Farm Napky, ca. 120–150 m (-BA), *Taylor 3777* (PRE), *Acocks 22593* (K, PRE).

Uncertain or inexact localities: on the banks of the Olifants R. and at Brakfontein, *Ecklon & Zeyher s.n.* sub PRE 21018 (PRE), *Drège "76.9"* (E); mtns. nr. Brakfontein, *Ecklon & Zeyher 2329* (SAM); on the banks of the Kenkorivier (?spelling), *Zeyher 2724* (K, S, SAM); between Stormsvlei and Bonnievale, *Acocks 1746* (S).

ACKNOWLEDGEMENTS

The present study would have been much less complete, had I not had invaluable assistance from numerous professional and amateur botanists while in South Africa between March 1976 and February 1977. Of all those who offered help in various ways, I would particularly like to thank Dr O. M. Hilliard (Pietermaritzburg) for her continued manifold support while at the University of Natal, to Dr J. P. Rourke (Kirstenbosch) for advice and help while at the Cape, to Mr B. L. Burt (Edinburgh) for many useful suggestions, and last but not least to Prof. Dr Ehrendorfer (Vienna) for constructive criticism and providing me with unpublished data.

For assistance at the SEM and processing of the photographs I am greatly indebted to Mrs M. G. Gilliland and Mr V. J. Bandu (EM-Unit, University of Natal). Finally, I would also like to thank the directors and curators of all herbaria whose material has been investigated on the spot or borrowed for their kind cooperation.

I am greatly indebted to Drs Hilliard and Rourke for critically reviewing the manuscript.

REFERENCES

- ACOCKS, J. P. H., 1975. Veld types of South Africa. 2nd Ed. *Mem. bot. Surv. S. Afr.* **40**.
 ADAMSON, R. S. and SALTER, T. M., 1950. *Flora of the Cape Peninsula*. Cape Town: Juta & Co.

- BRENAN, J. P. M. et COLL., 1953. Plants collected by the Vernay Nyasaland expedition of 1946 (part 2). *Mem. N.Y. bot. Gdn* **8**: 406–506.
- CUFODONTIS, G., 1965. Enumeratio Plantarum Aethiopiae Spermatophyta. *Bull. Jard. bot. État Brux.* **35**, Suppl.
- DRÈGE, J. F., 1843. Zwei pflanzengeographische Documente. *Flora* **2**, Beigabe.
- , 1847a. Standörter-Verzeichnis der von C. L. Zeyher in Südafrika gesammelten Pflanzen. *Linnaea* **19**: 583–598.
- , 1847b. Vergleichungen der von Ecklon und Zeyher und von Drège gesammelten südafrikanischen Pflanzen. *Linnaea* **19**: 599–680.
- , 1848. Standörter-Verzeichnis, Nachtrag. *Linnaea* **20**: 258.
- ECKLON, C. F. and ZEYHER, C., 1836. *Enumeratio plantarum africae australis extratropicae, pars 2*. Hamburg: Perthes & Besser.
- EDWARDS, D. and LEISTNER, O. A., 1971. A degree reference system for citing biological records in Southern Africa. *Mitt. bot. St Samml., Münch.* **10**: 501–509.
- EHRENDORFER, F. and VERDCOURT, B., 1973. Two new species of *Galium* (Rubiaceae-Rubieae) from tropical East Africa. *Kew Bull.* **28**: 485–489.
- FAGERLIND, F., 1937. Embryologische, zytologische und bestäubungsexperimentelle Studien in der Familie Rubiaceae nebst Bemerkungen über einige Polyploiditätsprobleme. *Acta Horti Bergiani* **11**: 195–470.
- GODLEY, E. J., 1964. Breeding systems in New Zealand plants. 3. Sex ratios in some natural populations. *N.Z. Jnl. Bot.* **2**: 205–212.
- , 1976. Sex ratio in *Clematis gentianoides* DC. *N.Z. Jnl. Bot.* **14**: 299–306.
- GRAY, S. F., 1821. *A natural arrangement of British plants*. Vol. 2. London.
- GIESS, W., 1971. A preliminary vegetation map of South West Africa. *Dinteria* **4**: 1–114.
- HOLMGREN, P. K. and KEUKEN, W., 1974. *Index herbariorum*. Part 1. The herbaria of the world. Ed. 6. Utrecht: Oosthoek, Scheltema & Holkema.
- KIRCHNER, O., 1911. *Blumen und Insekten*. Leipzig-Berlin: B. G. Teubner.
- LEISTNER, O. A. and MORRIS, J. W., 1976. Southern African place names. *Ann. Cape prov. Mus.* **12**: 1–565.
- LLOYD, D. G., 1973. Sex ratios in sexually dimorphic Umbelliferae. *Heredity, Lond.* **31**: 238–249.
- MARLOTH, R., 1932. *The Flora of South Africa* **3**. Sect. 2. Cape Town: Darters Bros. & Co.
- MOORE, R. J., 1975. The *Galium aparine* complex in Canada. *Can. J. Bot.* **53**: 877–893.
- MÜLLER, H. 1873. *Die Befruchtung der Blumen durch Insekten und die gegenseitige Anpassung beider*. Leipzig: Engelmann.
- PHILLIPS, E. P., 1917. A contribution to the Flora of the Leribe plateau and environs. *Ann. S. Afr. Mus.* **16**: 1–379.
- PUFF, C., 1974. Biosystematik der Formenkreise um *Galium palustre* L. und *G. trifidum* L. (Rubiaceae) auf der Nord- und Südhemisphäre. *Diss. phil. Fak. Univ. Wien*.
- , 1975. Morphologie, Biologie und Abgrenzung von *Galium* L. sect. *Aparinoides* (Jord.) Gren. (Rubiaceae). *Beitr. Biol. Pfl.* **51**: 17–40.
- , 1976a. The *Galium trifidum* group (*Galium* sect. *Aparinoides*, Rubiaceae). *Can. J. Bot.* **54**: 1911–1925.
- , 1976b. Über die *Galium palustre*-Gruppe (*Galium* sect. *Aparinoides*, Rubiaceae) in Österreich. I. Einige Chromosomenzahlen von *G. palustre* und *G. elongatum*. *Linzer biol. Beitr* **8**: 3–11.

- , 1977. Chromosome numbers of some Southern African Rubiaceae-Rubieae. *Linzer biol. Beitr.* **9**: 203–212.
- , 1978. A new combination in Rubiaceae-Rubieae of Southern Africa. *Kew Bull.* **32**: 432.
- SALTER, T. M., 1937. Notes on some species in the family Rubiaceae in the Cape Peninsula. *Jl S. Afr. Bot.* **3**: 109–116.
- SCHREBER, C. D., 1771. *Spicilegium florum Lipsicae*. Leipzig: Dyk.
- SKEAD, C. J., 1973. Zoo-historical gazetteer. *Ann. Cape. prov. Mus.* **10**: 1–259.
- SONDER, O. W., 1865. Rubiaceae. In: Harvey, W. H. and Sonder, O. W., *Flora Capensis* **3**. Dublin: Hodges, Smith & Co.
- STEUDEL, E. T., 1840. *Nomenclator botanicus*. Ed. 2, pars 1, lit. A-K. Stuttgart-Tübingen: Gott.
- TROLL, W., 1964. *Die Infloreszenzen*. Bd. 1. Jena: Borntraeger.
- VERDCOURT, B., 1975. Studies in the Rubiaceae-Rubioideae for the "Flora of Tropical East Africa": I. *Kew Bull.* **30**: 247–326.
- , 1976. Rubiaceae, part 1. In: Polhill, R. M. (ed.), *Flora of tropical East Africa*. London-Tonbridge: Whitefriars Press Ltd.
- ZIMMERMANN, W., 1932. Bemerkenswerte Rassen schwäbischer Pflanzen. *Jh. Ver. vaterl. Naturk. Württ.* **88**.

TAXA TO BE EXCLUDED

Galium horridum Thunb., Fl. Cap. 1: 556 (1813).

= *Rubia horrida* (Thunb.) Puff in Kew Bull. 32: 432 (1978).

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PHYTOSOCIOLOGICAL STUDIES ON TABLE MOUNTAIN, SOUTH AFRICA:

1. THE BACK TABLE

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ABSTRACT

The Braun-Blanquet phytosociological technique was used to describe the vegetation of a portion of the Back Table of Table Mountain. The fynbos vegetation was found to consist of two communities, one containing five sub-communities, while some patches of wet Kloof Forest occurred in well protected sites. Environmental factors, notably the moisture régime, were found to be important in determining the distribution of the plant communities.

UITTREKSEL

FITOSOSIOLOGIESE STUDIES OP TAFELBERG, SUID-AFRIKA:

1. DIE AGTERTAFEL

Die Braun-Blanquet fitososiologiese tegniek was gebruik om die plantegroei van 'n gedeelte van die Agtertafel van Tafelberg te beskryf. Dit het geblyk dat die fynbos plantegroei uit twee gemeenskappe bestaan, die een met vyf subgemeenskappe. Lappe klam kloofbos is op goed beskutte plekke gevind. Omgewingsfaktore, hoofsaaklik die beskikbaarheid van water, is as belangrike bepalende faktore vir die verspreiding van plantegroei gevind.

INTRODUCTION

The Back Table of Table Mountain (see Fig. 1) is covered by relatively unspoilt fynbos vegetation, when compared to the rest of the Mountain or even the entire Cape Peninsula.

The Back Table plateau is about 600 to 700 m above sea-level and about 200 ha in area (Fig. 2). It is divided by Disa Gorge and two reservoirs (Hely-Hutchinson and Woodhead).

It was decided that a phytosociological survey would contribute to an understanding of the vegetation of the Back Table, and that this survey would also be of use in a concurrent project concerned with the management and ecological status of the vegetation of the whole of Table Mountain (Moll and Campbell, 1976).

CLIMATE

Rainfall records from Table Mountain indicate that the highest annual precipitation on the Mountain occurs at Table Mountain House on the Back Table



FIG. 1.

Oblique aerial view, facing North, showing the Western escarpment on the left and Disa Gorge dividing the Back Table on the right-hand side. The two reservoirs and dense *Pinus pinaster* stands are just visible above the gorge.

(Schulze, 1965). The 1 780 mm annual precipitation comprises mainly winter rainfall, though mist in summer is frequent. The western slopes and Camps Bay by comparison receive 618 mm per annum, and Kirstenbosch on the eastern side receives 1 413 mm (see Fig. 3).

The mediterranean climatic zone of the Southwestern Cape with cool, wet winters and characteristically hot, dry summers, means that the greatest water shortage and heat stress on plants is imposed during the months January to March.

GEOLOGY AND SOILS

The underlying rock on almost the entire Mountain is Table Mountain Sandstone (Du Toit, 1954). Bedrock is often exposed. Soils vary in colour and are generally of a sandy consistency with little humus, though occasionally soil litter is locally abundant.

METHODS

The survey was carried out during the months March to June 1975 and for purposes of this survey only perennially identifiable species were recorded. Forty-eight relevés were sampled using the Braun-Blanquet technique as described by Werger (1974). Optimal plot size was considered to be 5×5 m for vegetation of a metre or less in height. Occasionally larger plots, 5×10 m and 10

$\times 10$ m (e.g. in Kloof Forest), were used. All data collected in the field (both environmental and floristic) were entered on a pre-printed field data sheet.

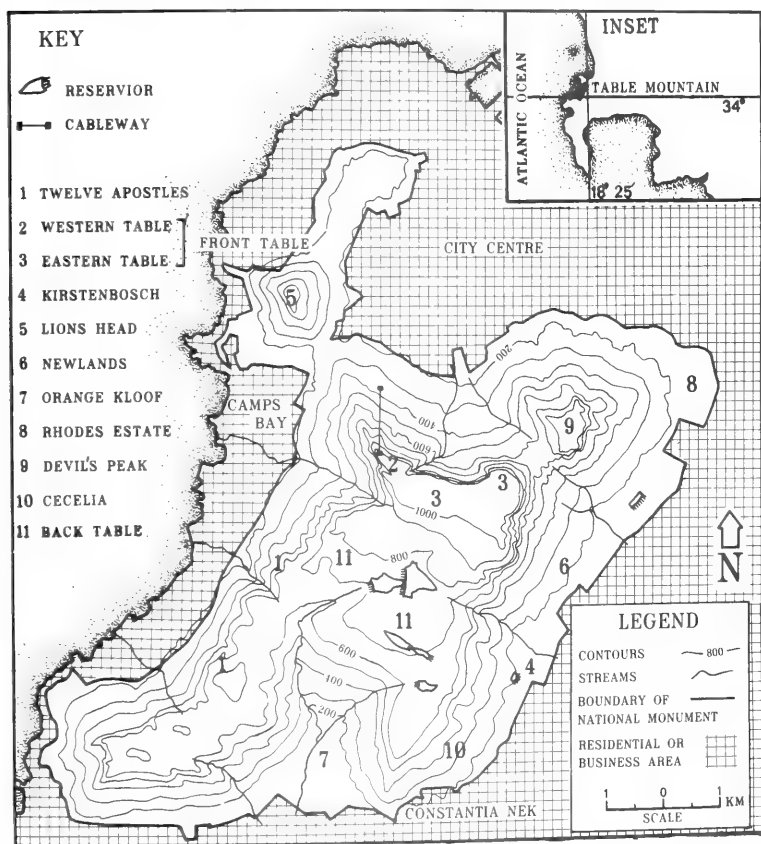


FIG. 2.

Topographic map of Table Mountain National Monument showing the location of the Back Table. Inset shows the position of Table Mountain on the Cape Peninsula.

The floristic data were sorted using a group-average method based on the Canberra similarity coefficient (Campbell and Moll, 1976). This was used to obtain relevé groups. The species were then subjectively re-arranged, and a final phytosociological table was constructed (Table 1). This classification was checked in the field and found to be consistent.

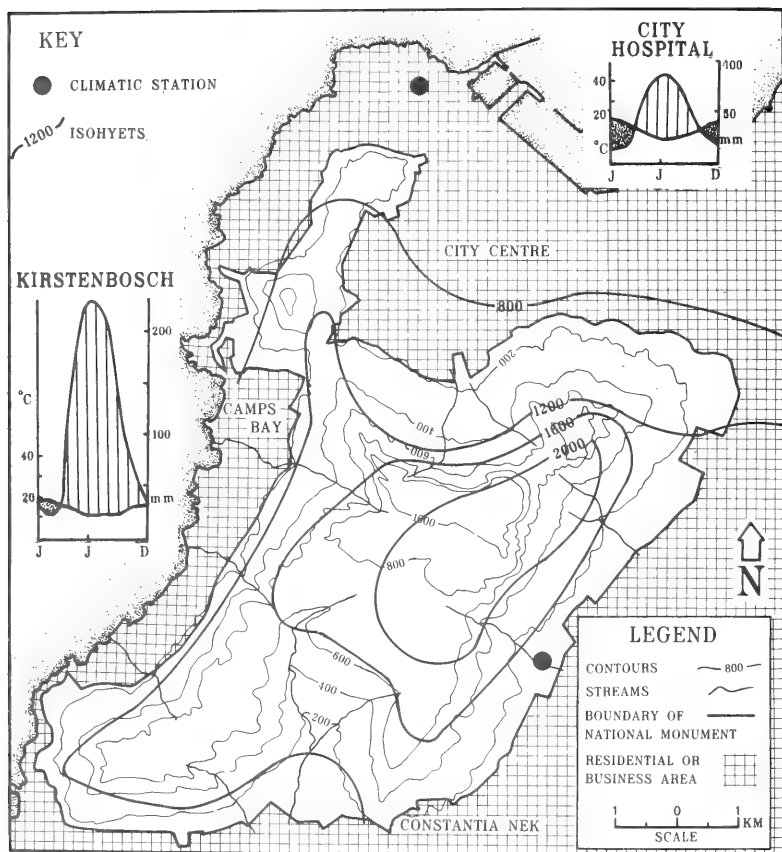


FIG. 3.

Map of the Table Mountain National Monument showing the major rainfall isohyets. Inset climate diagrams indicate the duration and intensity of wet and dry seasons for two stations representative of the climatic extremes of the area.

CLASSIFICATION OF THE VEGETATION

Three major plant communities occur on the Back Table:

1. *Ilex-Blechnum* Forest Community

This contains all the typical members of wet kloof forests in the Southwestern Cape, i.e. *Cunonia capensis*, *Ilex mitis* and *Halleria lucida* as canopy trees, and *Maytenus acuminata*, *Podocarpus latifolius* and *Olea capensis* as sub-canopy

Final phytosociological table.

Relevé Number	A	B	C	D	E ¹	E ²
Total number of species	55	48	170	179	171	177
Rock size: b=bedrock, l=2.5cm, 2=15cm, 3=6cm	3	3	3	2	3	0
Rock cover: Braun Blanquet cover	3	3	2	1	2	0
abundance scale	3	3	2	1	2	0
Soil depth: l= 15cm, 2=20 to 50cm, 3= 50cm.	1	1	2	1	2	1
Drainage: t=temporary moist, s= seasonally wet, w=wet	s	s	t	t	s	s
<i>Ilex-Blechnum</i> Community						
Differential species						
<i>Blechnum attenuatum</i>	4	1				
<i>Schoenocarpium lanceum</i>	1	3				
<i>Ilex mitis</i>	2	1				
<i>Asparagus scandens</i>	1	1				
<i>Maytenus acuminata</i>	1	0				
<i>Aleocolla capensis</i>	3					
<i>Acacia melanoxylon</i>	2	3				
Species common to <i>Ilex-Blechnum</i> Community and Sub-community A of the <i>Erica-Penaea</i> Community						
<i>Halleria lucida</i>	+ 2	1				
<i>Gunonia capensis</i>	4	4				
<i>Podocarpus latifolius</i>	1	2				
<i>Hartogia capensis</i>	1	1				
<i>Olea capensis</i>	1	0				
<i>Rapanea melanophloeos</i>	1	3				
Differential species of Sub-community A						
<i>Myrica humilis</i> /M. <i>diversifolia</i>						
<i>Cibbaria ilicifolia</i>	+ 1	1				
<i>Leucadendron strobilinum</i>	4	2				
<i>Rhus lucida</i> /R. <i>mucronata</i>	1	1				
<i>Protea cynaroides</i>	2	2				
Grass sp.						
<i>Myrsine africana</i>	3	0				
<i>Stilbe vestita</i>		1				
<i>Aleiopoe tabularis</i>	+	+				
<i>Peoralea aphylla</i>	+	+				
<i>Anemone capensis</i>	1	1				
<i>Cultumia ciliaris</i>	+	+				
<i>Peucedanum ferulaeum</i>	1					
<i>Diosma hirsuta</i>						
"Differential" species of Sub-community C						
<i>Restio cuspidatus</i>						
<i>Staberoha cernua</i>						
<i>Thesium scabrum</i>						
Species common to Sub-communities A, B & C						
<i>Tetragia thermalis</i>	1	1				
<i>Elegia juncea</i> /E. <i>racemosa</i>	1	2				
<i>Bobartia gladiata</i>	1	2				
<i>Bobartia indica</i>	+	1				
<i>Leptocarpus membranaceus</i>	+	1				
<i>Leucadendron xanthoconus</i>	2	+				
<i>Helichrysum gymnosum</i>	+	1				
<i>Peucedanum sieberianum</i>	+	1				
<i>Agapanthus africanus</i>						
Differential species of Sub-community D						
<i>Lampranthus falcoformis</i>						
<i>Coleonema album</i>						
<i>Phyllica dioica</i>						
<i>Philippia chamissonis</i>						
<i>Phyllica buxifolia</i>						
<i>Peucedanum galbanum</i>						
Species common to Sub-communities C & D						
<i>Corymbium glabrum</i>	+	1				
<i>Eria plukenetii</i>	+	1				
<i>Psoralea aculeata</i>						
<i>Cliffortia atrata</i>	2	1				
<i>Ehrharta ramosa</i>						
<i>Cliffortia ruscifolia</i>						
<i>Pinus pinaster</i>	1					
<i>Smocetilus depressus</i> /Piaeria sp.	+					
<i>Ficinia acuminata</i>	2					
<i>Thamnochortus dichotomus</i>						
Species of Sub-community E ¹						
<i>Chrisocharis capensis</i>						
<i>Gnidia humilis</i>						
<i>Ehrharta setacea</i>						
Species common to Sub-communities C, D & E ¹						
<i>Thamnochortis gracilis</i>						
<i>Danthonia macrantha</i> /Pentameris sp.	1	+				
<i>Psoralea pinnata</i>						
<i>Chondropetalum ebraeatum</i>						
<i>Danthonia lanata</i>						
<i>Euryops abrotanifolius</i> /Ursinia sp.	1	0				
Penaea-Erica Community						
Differential species						
<i>Penaea mucronata</i>	1	1				
<i>Erica hiapidula</i>	1	2				
<i>Watsonia</i> sp.	+	1				
<i>Hypodactys aristatus</i>						
<i>Cladia polygonoides</i>						
<i>Tetraria flexuosa</i>						
<i>Berseria lanuginosa</i>	1	1				
<i>Schizaea pectinata</i>	1	0				
<i>Tetraria cuspidata</i>	+	2				
<i>Restio bifidus</i>						
<i>Anthospermum aethiopicum</i>						
<i>Osmiotopsis astericoides</i>						
<i>Struthiolla ciliata</i>						
<i>Stoebe cinerea</i>						
<i>Cliffortia theodori-friesii</i>						
<i>Erica lutea</i>						
<i>Pentastichis</i> sp.						
<i>Roelia squarrosa</i>						
Erica mollis Community						
Differential species						
<i>Erica mollis</i>						
<i>Restio compressus</i>						
<i>Bulbinella floribunda</i>						
Species common to the Erica mollis Community & Sub-community E ² of the Erica-Penaea Community						
<i>Hypolaena erinalis</i>						
<i>Elegia thurstiflora</i>						
<i>Senecio crispus</i>						
Species common to the Erica mollis Community & Sub-community E of the Erica-Penaea Community						
<i>Villarsia ovata</i>						
<i>Chondropetalum mucronatum</i>						
<i>Mairia taniifolia</i>						

Species not included in the above table:

Adenandra umbellata 154,1; 177,+, 156,2; *Agathosma ciliata* 179,+, *Afrachneria capensis* 183,+, 184,+, *Anaxeton arboreus* 160,(+); 143,+, 144,+, *Apodytes dimidiata* 55,+, *Asplenium aethiopicum* 48,+, *Asplenium erectum* 48,+, *Blechnum australe* 162,+, 167,(+); 55,+, *Carpacoe spemacoea* 159,+, 177,+, *Cassine capensis* 48,1; *Cassytha ciliolata* 160,1; 162,1; *Centella eriantha* 170,1; 162,1; *Chondropetalum deustum* 144,+, 169,+, *Chrysocoma coma-aurata* 179,+, 162,(+); *Clusia pulchella* 48,+, *Epischoenus quadrangularis* 167,+, *Erepsia anceps* 143,+, *Erica abietina* 190,(+); 144,1; *Erica curvirostris* 144,+, 152,+, *Erica empetrifolia* 185,+, *Erica nudiflora* 190,+, *Erica obliqua* 169,+, *Ficinia filiformis* 171,1; *Ficinia* (species unidentified) 142,+, *Glia gumifera* 179,+, *Grubbia rosmarinifolia* 187,+, 174,+, *Hermas villosa* 182,+, 143,+, 187,+, *Helichrysum auriculatum* 151,(+); 189,+, *Helichrysum foetidum* 179,+, *Helichrysum vestitum* 183,+, 182,+, 142,+, *Hymenophyllum tunbrigense* 48,1; *Indigofera sammentosa* 184,+, 171,1; *Kiggelaria africana* 48,+, *Knoltonia capensis* 48,+, 170,+, *Leidesia procumbens* 48,+, *Lobelia pinifolia* 182,+, 143,+, 153,+, *Mairia arenata* 143,1; 165,+, 164,(+); *Melothria punctata* 48,+, *Metastasia divergens* 143,+, 144,+, *Nemesia lutea* 170,+, *Nemesia macrocarpa* 179,+, *Olinia gymosa* 48,+, *Osteospermum ciliatum* 184,+, *Othonna quinqueidentata* 181,+, *Pentastichis imperfeeta* 182,+, *Pentastichis pallens* 151,1; *Peperomia retusa* 48,+, *Phyllica strigosa* 153,1; *Pleopeltis lanceolata* 48,1; *Prismatocarpus sessilis* 142,+, *Pteridium aquilinum* 179,2; 167,3; *Protea grandiceps* 190,(+); 172,2; *Restio multiflorus* 155,+, 156,1; *Restio perpleus* 190,2; 180,(+); 150,1; *Restio* (unidentified species) 142,+, *Rochea coccinea* 144,+, 162,+, *Rochea subulata* 144,+, *Rubus pinnatus* 170,1; *Rumohra adiantifolium* 170,+, 167,(+); *Selago serrata* 144,+, 179,+, *Senecio grandiflorus* 179,+, 186,+, *Senecio bipinnatus* 170,1; *Senecio bipinnatus* 177,+, 179,+, 167,(+); *Senecio pubigerus* 184,+, *Senecio rigidus* 179,(+); *Stachys aethiopica* 48,(+); *Stoebe incana* 184,2; 169,+, *Tetragia brevicaulis* 154,+, 156,+, *Tetraria compar* 188,(+); 183,+, 165,+, *Thamnochortus lewyniae* 189,+, *Thesium carinatum* 184,+, *Ursinia dentata* 151,+, *Ursinia nudicaulis* 174,1; *Zantedeschia aethiopica* 48,(+).

trees. The ground layer has a high cover of *Blechnum attenuatum* in relevé 55 (situated in Disa Gorge), and *Schoenoxiphium lanceum* in relevé 48 (situated in a deep rock crevice east of Disa Gorge). Associated with both these relevés is *Asparagus scandens* which is generally ubiquitous in forest (Campbell and Moll, 1977). There is a constant stream of water through the gorge draining from Woodhead Reservoir, hence the presence of *B. attenuatum* and *Alsophila capensis*. It is disturbing to note that *Acacia melanoxylon*, a pestplant (Moll and Campbell, 1976), was also recorded here.

2. *Penaea-Erica* Fynbos Community

The five sub-communities of the *Penaea-Erica* Fynbos Community all contain one or more of the following five species: *Penaea mucronata*, *Erica hispidula*, *Watsonia* spp., *Hypodiscus aristatus* and *Clutia polygonoides*. This community occurs on both shallow and deep soils with little or much rock cover. With the exception of sub-community E, which is essentially a wetter sub-community, the *Penaea-Erica* Fynbos Community occurs on those seasonally moist to wet soils that show some flow of water through them. It is the most extensive community on the Back Table and varies from having a high component of forest species present where there is some protection from fire, to having a dry component present on well drained, exposed sites.

(i) *Sub-Community A* has as differential species such forest elements (Campbell and Moll, 1977) as *Rhus lucida*/*R. mucronata* and *Myrsine africana*, riverine



FIG. 4.

Sub-community C showing *Tetraria thermalis* and *Watsonia* spp. as well as tussocked restios such as *Hypodiscus aristatus*.

elements such as *Myrica humilus*/*M. diversifolia*, and *Psoralea aphylla*, and fynbos elements such as *Leucadendron strobilinum* and *Protea cynaroides*. Because of the presence of the forest elements the sub-community is placed adjacent to the *Ilex-Blechnum* Community on Table 1.

(ii) *Sub-community B* is a depauperate form of sub-community A, probably as a result of more frequent burning as indicated by the presence of such species as *Tetraria thermalis* and *Bobartia gladiata* (Fig. 4). Both sub-community A and B occur on shallow to deep, rocky soils.

(iii) *Sub-community C* is apparently intermediate between sub-communities A and B, the wetter sub-community E, and sub-community D which is the driest sub-community of the *Penaea-Erica* Fynbos Community (Fig. 7).

Bedrock is exposed in all relevés except 180, which had a high cover abundance of *Pinus pinaster*, a non-indigenous tree species. Relevé 180 had only 14 species (average for C is 22,5) and it is suggested that relevé 180 may have been in sub-community A if *P. pinaster* was absent.

The species that distinguish sub-community C as a nodum in the phytosociological table are essentially those that dominate with frequent burning, namely *Tetraria thermalis*, *Bobartia gladiata*, *Corymbium glabrum* and *Psoralea aculeata*.

(iv) *Sub-community D* is a drier form of sub-community C occurring on shallower, rocky, well drained soils in exposed situations. The differential species



FIG. 5.

Cliffortia ruscifolia and *Lampranthus falciformis* on shallow, rocky, well-drained soils.

is *Lampranthus falciformis*, and *Cliffortia ruscifolia* is also present in every relevé (see Fig. 5).

(v) *Sub-community E* occurs on wetter sites with relatively deep soils. Two variations are apparent, one on soils with a low rock cover, and one on soils with an intermediate rock cover. This sub-community is related to the second fynbos community recognised on the Back Table, namely the *Erica mollis* Fynbos Community, but because of the presence of such species as *Penaea mucronata*, *Erica hispidula* and *Hypodiscus aristatus* it is classified as part of the *Penaea-Erica* Fynbos Community.

3. *Erica mollis* Fynbos Community

The differential species of this community are *Erica mollis*, *Restio compressus* and *Bulbinella floribunda*. The community occurs on deep, wet, poorly drained soils. Where the drainage is better this community abuts on to the wetter variation of sub-community E (i.e. E²) of the *Penaea-Erica* Community and species which are common to the two communities are *Hypolaena crinalis* (Fig. 6) and *Elegia thyrsoiflora*. Some species, such as *Villarsia ovata* and *Chondropetalum mucronatum*, are even more widespread and also occur in the drier variation of sub-community E (i.e. E¹).



FIG. 6.

Hypolaena crinalis with *Chondropetalum mucronatum* (large tussocks) in a wet area. Note the pines in the background.

CONCLUSIONS

1. The Braun-Blanquet phytosociological technique and the computerised sorting method of Campbell and Moll (1976) are well suited to the survey of fynbos vegetation on the Back Table.

2. The apparently uniform fynbos vegetation of the Back Table was found to be composed of two communities; one containing five sub-communities.

3. These communities and sub-communities are linked to environmental factors, especially the moisture régime, as may be expected on a plateau where aspect is not important.

4. The relationships between the major plant communities and the environmental factors are best summarised diagrammatically (Fig. 7).

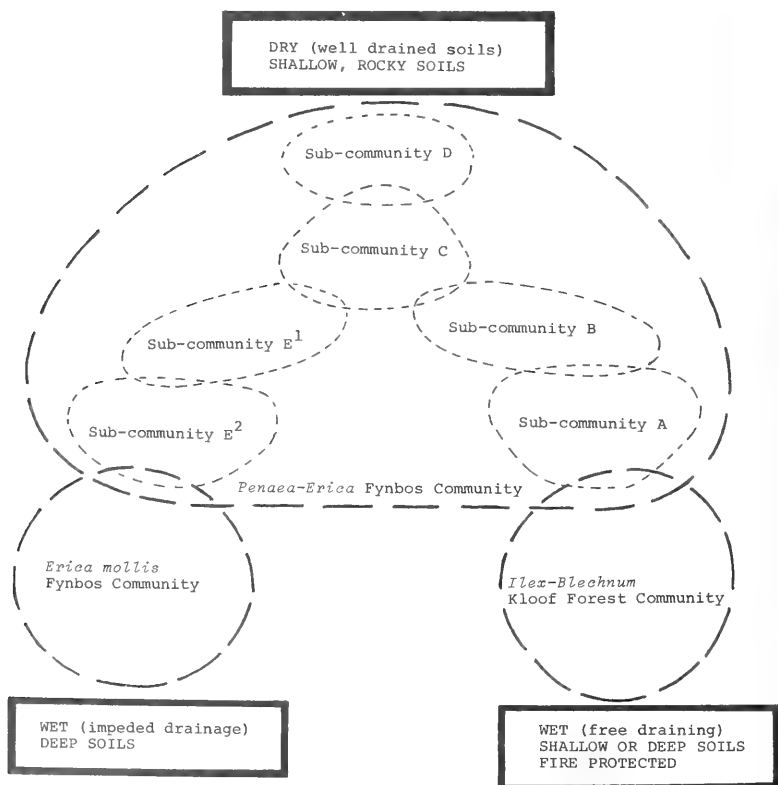


FIG. 7.

Ordination showing the relationships between the three communities and five sub-communities, and the major environmental factors on the Back Table.

ACKNOWLEDGEMENT

The authors would like to thank Miss E. Esterhuysen of the Bolus Herbarium for many identifications.

REFERENCES

- CAMPBELL, B. and MOLL, E. J., 1976. On numerical methods for classifying relevés collected in Braun-Blanquet phytosociological surveys. *Jl S. Afr. Bot.* **42** (1): 45–56.
- CAMPBELL, B. and MOLL, E. J., 1977. The forest communities of Table Mountain, South Africa. *Vegetatio* **34** (2): 105–115.
- DU TOIT, A. L., 1954. *The Geology of South Africa*. London and Edinburgh: Oliver and Boyd.
- MOLL, E. J. and CAMPBELL, B. M., 1976. *The ecological status of Table Mountain—a report on the present conservation status and recommendations for the future management of the National Monument*. Cape Town: Dept of Botany, University of Cape Town. ISBN 0 7992 0174.
- SCHULZE, B. R., 1965. *Climate of South Africa*. Part 8: General Survey. Pretoria: Government Printer. 330 pp.
- WERGER, M. J. A., 1974. On concepts and techniques applied in the Zurich-Montpellier method of vegetation survey. *Bothalia* **11** (3): 309–323.

PHYTOSOCIOLOGICAL STUDIES ON TABLE MOUNTAIN, SOUTH AFRICA:

2. THE FRONT TABLE

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ABSTRACT

The Braun-Blanquet phytosociological technique was used to describe the vegetation of the study area. Two communities, one with two sub-communities and an ecotonal community between the two sub-communities, are recognised. The siting of the Cableway station, with the attendant large volume of tourist traffic, has led to serious vegetation degradation in the immediate vicinity. Some recommendations as to how this situation may be improved are given.

UITTREKSEL

FITOSOSIOLOGIESE STUDIES OP TAFELBERG, SUID-AFRIKA:

2. DIE VOORTAFEL

Die Braun-Blanquet fitososiologiese tegniek was gebruik om die plantegroei te beskryf. Drie gemeenskappe, gebaseer op omgewingsfaktore en flora word erken. Die plasing van die Sweefspoorstasie met die gepaardgaande groot volume besoekersverkeer het tot ernstige agteruitgang van die plantegroei van die area gelei. Voorstelle word gemaak om die toestand te herstel.

INTRODUCTION

The study area was the Front Table of Table Mountain, above the 1 000 m contour (see Fig. 2. in Glyphis, Moll and Campbell, 1978). The plateau is roughly triangular in shape with the long axis orientated east-west, about 3 km long. A geological fault, Platteklip Gorge, divides the plateau into an Eastern and a Western Table.

GEOLOGY AND TOPOGRAPHY

The underlying rock of the plateau is Table Mountain Sandstone (Du Toit, 1954). Between exposed areas of bedrock and boulder formations a coarse white or grey sand overlies a dark humic soil; combined these two layers average approximately 200 mm in depth.

Drainage is variable with the flat areas near the plateau centre becoming water-logged during the rainy season, while those on the periphery of the plateau are usually well drained. Around the periphery there are also seepage areas and

Accepted for publication 3rd November, 1977.

poorly drained rock beds with dark grey, or black soils to depths of about one metre; these are usually wet, or at least moist, throughout the year.

CLIMATE

Table Mountain lies in a mediterranean climatic region, characterised by hot, dry summers and cool, wet winters. The Front Table has a mean annual rainfall of 1 440 mm, recorded at the Upper Cableway station (Schulze, 1965). Mists, carried over the plateau by the summer south-easterly winds, were shown by Marloth (1903, 1905) and Nagel (1956, 1962) to be a very important additional source of moisture. The winter rainfall and summer mists, therefore, ensure that the plateau has almost year round precipitation (see Fig. 3 in Glyphis, Moll and Campbell, 1978).

Temperature variation over the whole Mountain, in different seasons, is not pronounced. On the plateaus (front and back) the mean monthly temperature varies from 18 °C in summer to 7 °C in winter (Schulze, 1965).

METHODS

The Braun-Blanquet phytosociological technique, as described by Werger (1974), was used in this survey. Site selection and distribution of relevés was subjective. Only perennially identifiable species were recorded. A relevé area of 5 × 5 m was used and was found to be adequate as few species were found outside each plot. A total of thirty-eight relevés were sampled and the floristic and environmental data collected were entered on a standard field-sheet for each relevé.

Using a computer programme coefficients of similarity for each relevé, based on floristic data, were calculated (Campbell and Moll, 1976). From this information a dendrogram, showing the floristic relationship of the relevés, was drawn. Dendrogram groups, with certain minor adjustments, were used to construct the final phytosociological table. Species sequence in the table was arranged subjectively (Table 1).

DISCUSSION

Description of the Communities

1. *Maytenus*—*Athanasia* Community

The single relevé (140) is provisionally used to describe this community, which occurred on a rocky, well-drained, steep cliff where the soil was dark grey to black, and from 100 to 300 mm deep. The relevé itself was sited near the Upper Cableway station and contained, in addition to the dominants *Maytenus oleoides* and *Athanasia parviflora* the following species, *Salvia africana*, *Myrsine africana*, *Peucedanum galbanum*, *Cliffortia ruscifolia*, *Anthospermum aethiopicum* and *Ehrharta ramosa*.

Differential species

Hypolaena orninalis
Restio compressus
Senecio crispus

Elegia-Pentaschistis variation Differential species

Elegia thrysiflora
Erica sp.
Pentaschistis pallescens
Berzelia lanuginosa

Restio Community
Differential species
Chondropetalum ebracteatum
Urceiul nudicaulis
Ehrharta setacea
Chondropetalum mucronatum
Villarsia ovata
Restio sarcoclados

Accompanying species

Erica mollis
Grubbia rosmarinifolia
Pentaschistis colorata
Helichrysos cymosum
Adenandra umbellata
Gibbbaria ilicifolia
Lampranthus falseiformis
Mairia crenata

Species not included in the table above:

Carpacoc spermacoea 139+, 233+; *Centella eriantha* 249+; *Cheilanthes multifida* 140+; *Clusia alaternoides* 139(+); *Cultuma ciliaris* 139+; *Diosma oppositifolia* 235+; *Elegia neesia* 243+; *Episcoenus quadrangularis* 234,2, 139+; *Erica dicomaefolia* 138+; *Erica emetrefolia* 298+; *Erica* (species unidentified) 296+; *Euryops pectinatus* 140+; *Ficinia acuminata* 138+; *Ficinia composita* 140+; *Ficinia* (species unidentified) 225+; *Ficinia zeyheri* 243,2; *Helichrysos grandiflorum* 138+; *Hermas villosa* 138+; *Leontonyx spathulatus* 238,2; *Metacasia divergens* 239+; *Myrica humilis/diversifolia* 139+, 137+; *Nemesia lucida* 140+; *Othonna quinqueidentata* 243,2; *Pentaschistis aspera* 140+; *Pentaschistis curvifolia* 244+, 230,1; *Protea cynaroides* 139(+); *Prismatocarpus sessilis* 238(+); *Psoralea pinnata* 139,1; 243+; *Selago spuria* 230(+); *Senecio bipinnatus* 139(+); *Senecio rigidus* 140+; *Stoebe cinerea* 242(+), 243,1; *Struthiola ciliata* 137+; *Tetraria brevicaulis* 297(+), 244+; *Tetraria triangularis* 138,1, 243,1; *Thesium strictum* 241+, 240+; *Urstia dentata* 243+.

2. *Restio* Community

The major physiognomic component of the upper plateau is a closed *Restio* Community less than 1 m tall, in which *Chondropetalum ebracteatum*, *Ursinia nudicaulis*, *Ehrharta setacea*, *Chondropetalum mucronatum*, *Villarsia ovata* and *Restio sarcoclados* are the differential species. Two major sub-communities, separated by a fairly well-differentiated ecotonal group of species (G) occur within the *Restio* Community.

(i) *Watsonia-Penaea* Sub-community (A to F). This sub-community occurs on the shallow, essentially pallid soils overlying bedrock (see Table 2) and has been burnt fairly frequently in recent years. Important differential species, apart from *Watsonia* spp. and *Penaea mucronata*, are *Cliffortia ruscifolia*, *Thamnochortus nutans* and *Erica hispidula*. It is noteworthy that *T. nutans*, which is common on the upper plateau, has an extremely limited distribution in the Fynbos Biome as a whole, being restricted to the top of Table Mountain and the top of the Constantiaberg on the Cape Peninsula.

Within the sub-community there occur a number of variations, these are discussed below:

The *Restio-Schizaea* variation (B) occurs on the temporarily moist, relatively steep sites and has as differential species *Restio perplexus*, *Schizaea pectinata*, *Aristea* spp., *Cassytha ciliolata* and *Anemone capensis*. On wetter, flatter sites, with shallow soils, *Simocheilus depressus* and *Erica plukenetii* which also occur in this variation, are able to grow successfully indicating an ecotonal type (A). On somewhat deeper, pallid soils that have not been burned for five or seven years *Tetraria cuspidata* and *Leucadendron strobilinum* are more common (C), and where fire has burned the vegetation recently *Euryops abrotanifolius*/*Ursinia* sp. and *Elegia* spp. occur, but *Erica coccinea* and *L. strobilinum* are absent (D).

On those shallow, pallid soils that have a high surface rock cover a *Centella* variation occurs (E). Differential species of this variation, apart from *Centella caespitosa*, are *Helichrysum pinifolium*, *Chondropetalum deustum* and *Anaxeton arborescens*. On flatter sites where the surface rock cover is less *Centella* does not occur and *Restio bifidus* and *Chrysothrix capensis* form an ecotonal variation (G) between the *Watsonia-Penaea* Sub-community and the *Restio-Hypolaena* Sub-community. Here the topography is relatively flat, soils deeper, rock cover is low, and *Restio bifidus*, *Chrysothrix capensis*, *Afrachneria capensis* and *Stoebe incana* are more frequent.

(ii) *Restio-Hypolaena* Sub-community (H & I). This sub-community occurs on deeper, essentially pallid, seasonally wet soils on relatively flat sites. Differential species are *Hypolaena crinalis*, *Restio compressus* and *Senecio crispus*. Two variations, one characterised by *Elegia thrysiflora*, *Erica* sp., *Pentachistis pallens* and *Berzelia lanuginosa* on the deepest soils (I), and the other characterised by the absence of these species and high cover abundance values of *H. crinalis*, occur (H).

Anthropogenic influences

The location of the Upper Cableway station on the Western Table is responsible for a large volume of tourist traffic on the Front Table. This has resulted in extensive degradation of the vegetation especially within close proximity of the station and restaurant. Further away there is also much damage and despoilment along the edges of the foot-paths particularly along the front face.

It is, therefore, strongly recommended that well landscaped paths be constructed in areas where degradation is visible. This would, in fact, entail the planning of the path network on the whole Western Table, so that a few major routes are hardened. Visitor access should then be restricted to these paths to prevent further extensive degradation of the plant communities and allow their recovery.

CONCLUSIONS

Two distinct plant communities are recognised and described using the Braun-Blanquet phytosociological technique. One community, the *Restio* Community, has two sub-communities and an ecotonal variation. The important environmental factors determining these communities are soil depth, moisture content and rock cover. The trampling of the area by visitors to Table Mountain is causing concern regarding the future conservation status of the *Restio* Community.

ACKNOWLEDGEMENT

The authors would like to thank Miss E. Esterhuysen of the Bolus Herbarium for many identifications.

REFERENCES

- CAMPBELL, B. M. and MOLL, E. J., 1976. On numerical methods for classifying relevés collected in Braun-Blanquet phytosociological surveys. *Jl S. Afr. Bot.* **42**(1): 45–56.
- DU TOIT, A. L., 1954. *The Geology of South Africa*. London and Edinburgh: Oliver and Boyd.
- GLYPHIS, J., MOLL, E. J. and CAMPBELL, B. M., 1978. Phytosociological studies on Table Mountain, South Africa: 1. The back Table. *Jl S. Afr. Bot.* **44** (3): 281–289.
- MARLOTH, R., 1903. Results of experiments on Table Mountain for ascertaining the amount of moisture deposited from south-east clouds. *Trans. S. Afr. phil. Soc.* **14**: 403–408.
- MARLOTH, R., 1905. Results of further experiments on Table Mountain for ascertaining the amount of moisture deposited from the south-east clouds. *Trans. S. Afr. phil. Soc.* **16**: 97–105.
- NAGEL, J. F., 1956. Fog precipitation on Table Mountain. *Q. Jl. R. met. Soc.* **82**(354): 452–461.

- NAGEL, J. F., 1961. Rainfall in the Table Mountain area with special reference to orographic effects. *Weather Bureau Notes, Pretoria* **10**: 59–73.
- SCHULZE, B. R., 1965. *Climate of South Africa*. Part 8: General Survey. Pretoria: Government Printer. 330 pp.
- WERGER, M. J. A., 1974. On concepts and techniques applied in the Zurich-Montpellier method of vegetation survey. *Bothalia* **11**(3): 309–323.

AN INVESTIGATION INTO THE ECOLOGY AND PRODUCTIVITY OF EPIPHYTIC MOSSES

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ABSTRACT

Experimental harvesting of moss was undertaken for five years at two Transvaal localities. Determination of productivity was the main aim. It was established that mosses are very slow growing and require a minimum of seven to 10 years after harvesting to regenerate. Annual production amounted to 4 700 g/ha which is only 7,64 % regrowth, while biennial plots exhibited 15,45 % regrowth and triannual plots produced 27,38 % of the initial harvest. As Transvaal only has approximately 15 959 hectares of harvestable moss (5 426 002 kg), which on a sustained yield basis can be divided into 2 279,83 ha yielding 775 143 kg moss/annum on a seven year basis while over 10 years, 1 595,88 ha could be harvested with a sustained yield of 542 600 kg/annum.

UITTREKSEL

'N ONDERSOEK NA DIE EKOLOGIE EN PRODUKTIWITEIT VAN EPIFITIESE MOSSE

Eksperimentele versameling van mos is vir vyf jaar by twee Transvaalse lokaliteite gedoen. 'n Bepaling van die produktiwiteit was die hoofdoel. Daar is vasgestel dat mosse baie stadig groei en 'n minimum van tussen 7 en 10 jaar na dit geoes is, word benodig om te herstel. Die jaarlikse produksie was 4 700 g/ha wat slegs 'n 7,64 % herstel verteenwoordig terwyl persele wat elke tweede jaar geoes is 'n herstel van 15,45 % en persele wat na drie jaar geoes is 27,38 % van die oorspronklike oes gelewer het. Aangesien Transvaal net sowat 15 959 ha oesbare mos het (5 426 002 kg), kan dit teen 'n volgehoue basis in 2 279,83 ha gedeel word om 775 143 kg mos/jaar te lewer op 'n sewejarige basis terwyl daar oor 10 jaar van 1 595,88 ha 'n volgehoue produksie van 542 600 kg/jaar geoes kan word.

INTRODUCTION

On account of their water holding capacity epiphytic mosses are widely utilised by florists to pack flowers for shipment, for floral arrangements and for exhibition purposes. This has resulted in a demand for moss, that is harvested by Bantu gatherers and sold to the florists. The moss is harvested in the indigenous forests of the Transvaal, mainly in the east, along the Transvaal Drakensberg but also in the Soutpansberg. As these areas are the main source of moss in the Transvaal and because of the limited area covered by indigenous forest, the supply of moss is likewise limited. In addition, as large areas of forest lie in Bantu homelands, the protection afforded them by the Department of Forestry falls away and these areas are being severely cut back by indiscriminate woodcutting, burning and the foraging of livestock.

Accepted for publication 15th December, 1977.

In view of these limitations in the supply of moss, the harvesting on a large scale was considered with concern by the Division of Nature Conservation and mosses were placed on the list of Transvaal Protected Plants. The demand of the florists was however not ignored and an investigation into the ecology and production of mosses was initiated by Mr J. Jooste of the Division of Nature Conservation to determine the effects of harvesting, so that effective management, with the object of a sustained yield could be instituted. Adequate permits could then be issued to avoid over-exploitation. The aims of the project were therefore essentially threefold:

- (a) Determination of the amount of epiphytic mosses in the indigenous montane forests of the Transvaal.
- (b) Determination of the time it takes for the moss to regenerate fully after harvesting.
- (c) Determine the areal percentage which can be annually harvested on a sustained yield basis.

METHODS

For a determination of the total amount of harvestable moss it was necessary firstly to establish the total area in which moss occurs. Areas of indigenous forest were calculated from existing maps and aerial photographs with the aid of a planimeter, after local inspection to check on the distribution of moss.

In two areas, namely Woodbush and the farm Bloemfontein in the Soutpansberg, plots 100 square metres in extent were laid out. In the former a series of five plots was set out initially in June 1970, of which one (E) could not be re-located a month later (Jooste, 1971). This was followed by another set of 10 plots during July, 1972. The former set was used for annual growth checks, while five of the latter were used for biennial checks and the remaining five for triannual checks on regeneration. At Bloemfontein a set of five plots was set out and harvested annually during January.

The plots were laid out in various sections of the forests so as to cover a variety of microclimates ranging from dry to wet. The selection of plots was arbitrary and their suitability visually estimated. Each plot was beacons off with numbered wood or iron poles at the corners.

During 1972 all the plots at Woodbush were subdivided into quarters, (subplots), in order to establish whether any variations existed within each plot as a result of climatic or other local factors.

To determine the surface area, the trees within the plots were measured to an arbitrary height of two metres, based on the assumption that the Bantu gatherers did not harvest beyond that point. The circumference of the trees was measured at one metre from base and multiplied by the arbitrary height thus giving the area of the tree trunk. In cases where the trees had large buttress roots measurements were taken from where the trunk became vertical.

The moss was harvested by hand, placed in plastic bags and then sorted to remove foreign material such as pieces of bark and soil. It was then transferred into paper bags, oven dried over a period of 24 hours at 85 °C (185 °F) and weighed.

The average weight of moss per plot (100 m²) was used to calculate the amount of harvestable moss available.

For a determination of the time taken for moss to regenerate completely the plots were visited and harvested annually. The two and three year plots at Woodbush were harvested during 1974 and 1975 respectively. It must be stressed here that harvesting during experimentation was more severe than that of the Bantu gatherers who removed only the moss which was readily available.

RESULTS

Area determination

In the area calculations allowances were made for roads and open areas. These calculated areas are set out in Table 1. Excluded are the indigenous forests on the farm Bloemfontein in the Soutpansberg, in the Blyde River Canyon and in the Sabi area. The tabulation, however, contains the major areas of forest which were investigated.

TABLE 1.

Surface area of indigenous forest and surface covered by moss in the various plantations.

Area	Total area of indigenous forest (hectares)	Area in which moss is found (hectares)
Hanglip	206,78	190,20
Woodbush	4 271,50	3 630,76
De Hoek	2 355,43	2 143,46
Mariepskop	3 039,35	2 811,39
Entabeni	1 711,38	1 608,67
Salique	2 819,04	2 678,09
New Agatha	2 197,24	2 087,37
Roodewal/Goedehoop	337,22	320,35
N. Tvl. S.A.B.T.	463,45	444,91
Nieshoutsfontein LS 957	43,63	43,63
TOTAL	17 444,02	15 958,83

In the Bantu homeland area of the Soutpansberg only the farm Bloemfontein was found to have moss in harvestable quantities. The area of indigenous forest does not cover more than about 300 hectares, parts of which are rapidly being destroyed so that this area can probably be ruled out as a future source, especially as illegal harvesting of moss is adding to a swift deprivation (P. W. de Wet Wessels, pers. comm.)

The total area of indigenous forest in the Transvaal with the exception of small areas scattered in the east and north east is thus 17 444 hectares, of which 91,49 % or 15 959 hectares contain epiphytic mosses. This is only 0,06 % of the total land area of the Transvaal which fortunately, however, falls mainly under the Department of Forestry and is thus afforded some protection.

Regeneration Period

The moss is harvested manually by the Bantu gatherers to a height of two metres. Experimental harvesting extended over the six year period 1970–1975, though only for five years on the farm Bloemfontein, while at Woodbush the year 1971 was excluded as the initiator of the Project left the Division and the author continued with the Project only in 1972. Annual harvesting therefore took place at both sites for four consecutive years. Unfortunately the first year of reharvesting resulted in some discrepancies as may be seen on Table 2. This may be due to varying sampling techniques as it was not always possible to recognize which trees had previously been harvested, the present author not having accompanied the initial researcher during his visits, so that perhaps different standards were used in determining the extent of harvesting. The greatest discrepancy lies in the method of measuring the surface area, that is circumference and height. The method used by the present author is noted above. When comparing the figures from Bloemfontein it will be noticed that in plot C the difference in surface area between 1971 and 1972 is very great and probably due to measuring error, as it is doubtful that the growth rate on 35 trees would vary to such an extent.

When the present author took over, all the trees within the plots were re-measured and subsequently over the following three years only those trees with harvestable moss were measured so that moss regrowth per unit area could be established and compared. Large differences in the weights of moss per unit surface area such as are exhibited by plots A and C could also be due to the harvesting of certain moss species which were not reaped by the previous worker. As there was no request for species determination, it was thought best to harvest all moss species on the trees within the plots and this procedure was adhered to throughout the duration of the project. No change in species diversity was observed throughout the duration of the study and regeneration was apparent from the moss remnants left behind after the previous harvesting. In some instances young plants were seen germinating in areas which were moister than the surroundings but these seedlings appeared to be the same species as the adults harvested on the same trunks. One of the commoner species involved was *Papillaria natalensis* Sim. Florists utilise the moss irrespective of length or species. The results of the harvesting are shown on Tables 2, 3 and 4 in the Appendix.

From these it is evident that experimental harvesting has a considerable influence on the regeneration of moss. Particularly noteworthy is the reduction in

the number of trees with harvestable moss among the annual plots, both sites showing similar trends in the fluctuations of average numbers of trees per plot per annum. (Table 5(a) and (b)).

TABLE 5.
Fluctuations in average number of trees per plot per annum.

(a) Woodbush

	1972	1973	1974	1975	Total	Ave
A	23	19	17	12	71	17,75
B	30	13	22	14	79	19,75
C	30	9	18	15	72	18,00
D	17	0	9	9	35	8,75
Total	100	41	66	50	257	
Ave	25	10,25	16,5	12,5	64,25	

(b) Bloemfontein

	1972	1973	1974	1975	Total	Ave
A	25	15	21	16	77	19,25
B	27	1	21	11	60	15,00
C	35	0	10	8	53	13,25
D	23	1	NR	NR	24	12,00
E	17	0	0	6	23	5,75
Total	127	17	52	41	237	
Ave	25,4	3,4	13,0	10,25	59,25	

NR = not recorded during 1974-1975

These fluctuations are mainly due to the fact that moss regenerates very slowly, particularly after the first severe harvesting to which it is subjected. Consequently when the sites are re-visited only those trees with moss of harvestable length, that is one centimetre or more, are measured, while those which have moss of only very short growth are left until sufficient re-growth permits harvesting at later visits. The fluctuations are also documented in the graphs (Fig. 1) showing the annual yield of moss per plot. However, an average of the fluctuating yields will give a better picture as to the amount of regenerated moss per year. Over the three years subsequent to 1972 the average yield of moss harvested per plot from Woodbush and Bloemfontein amounts to 47 grams and 45 grams (dry weight) respectively (see Tables 2 and 3). In contrast the biennial plots yielded an average of 69 grams per plot and it is noticeable that only 48,5 % of the trees had harvestable moss after two years. The triannual plots show a substantial increase and an average of 101 grams per plot was harvested. However, only 51 % of the trees were found with harvestable moss representing only a slight increase on the biennial plots and the equal percentage to the average of the annual plots. It, therefore, appears that at Woodbush approximately 50 % of the trees remain barren after being harvested and that the moss requires a longer period to regenerate on them.

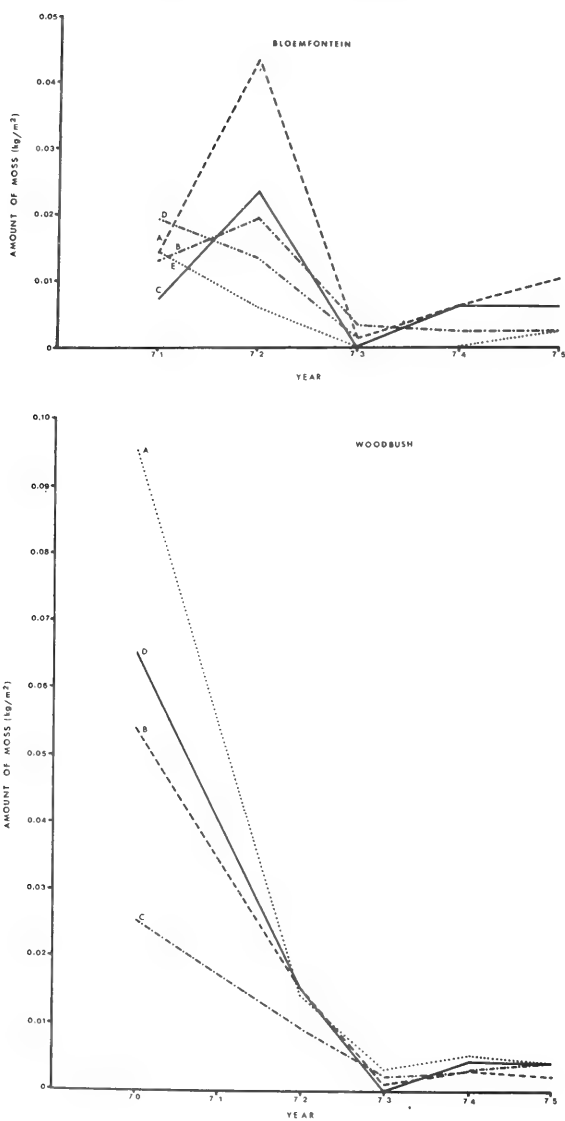


FIG. 1.
Annual fluctuations in the amount of moss harvested.

Factors controlling Re-generation

There are a number of factors which influence the regrowth of moss. Prior to harvesting, the moss hangs festooned from the trunks and branches of the trees as also from rocks in the forest. Moss grows more profusely in a relatively closed canopy forest than in an open forest where penetration by wind and sunlight causes dehydration. The plots laid out in the forest aimed at the investigation of these variations. This is clearly demonstrated at Woodbush when plots A and C are compared, the former giving much larger yields than the latter. A similar variation was observed at Bloemfontein.

Slope aspect appears to influence the growth of moss as it frequently only grows on one side of the trunk, leaving the opposing side bare. This, no doubt, is due to the prevailing weather conditions which bring more moisture to the exposed side of the tree trunk while the other side remains in a partial rain shadow. Higher up the tree the disparity disappears.

At Woodbush the E, SE and S sides of the stems have the most luxurious moss cover. The same applies to younger trees where the bark is usually smoother than in the adult stage and here it needs several years for the moss to establish itself.

Rough bark is more densely moss-covered because its rugosity offers innumerable places for the moss spores to lodge. It also collects falling dust and humus which lodge in the cracks and form a growth medium in which the spores can germinate, enhanced by a higher degree of water retention as compared with smooth bark which dries fairly rapidly after rain. Harvesting moss from the former is more difficult than from the latter as usually only the easily removable portion of the plants is taken, whereas the moss on smooth trees frequently comes away entirely with stolons and rootlets so that nothing is left for regeneration. Doubtlessly this has a great influence on the assessment of the number of trees with harvestable moss.

Areas in which the undergrowth is relatively dense also appear to produce more moss due to protection from wind and sunlight, while transpiration by the shrubs and herbs also contributes to a moister microclimate. This was seen at Woodbush where moss growing on tree trunks in the herbaceous layer was longer than that on the same tree trunk in a more exposed position.

The influence of Moisture

There does not appear to be a well defined correlation between the amount of moss production and rainfall, but it is felt that this is the case between the growth of moss and the number of misty days per annum. This view is supported by the fact that the average amount of growth of moss per plot at Woodbush and Bloemfontein is very similar although the average rainfall at Woodbush over the four year period 1969 to 1972 is 2.5 times as much as that at Bloemfontein. Taking the three most favourable plots at Woodbush and Bloemfontein, a marked similarity in the amount of regrowth of the epiphytic mosses is revealed.

Experiments undertaken by R. Marloth (Wellington, 1955) on top of Table Mountain showed that during a period of 21 days, the rainfall gauge registered nil whereas a gauge adapted to condense moisture from mist recorded 758,4 mm. On a previous occasion (January-March 1904) the rain gauge also recorded nil whereas the mist gauge registered 484,4 mm. This stresses the importance of mist as a source of moisture especially as it occurs throughout the year in the areas where moss grows. Condensation occurring on the leaves and boles of trees runs down the trunks providing a direct water supply to the moss, besides a certain amount of moisture from the mist which may be absorbed directly. This process was noticed on the Downs in the eastern Transvaal Drakensberg where water was seen streaming down the boles of the trees. Unfortunately there is no record of the number of misty days per annum at either site, so that a numerical correlation is not possible.

Both areas have a similar rainfall pattern with a pronounced peak during the four months December, January, February and March (Table 6). Although on the average rainfalls occur throughout the year there is a distinct minimum during the winter months. Bloemfontein is more arid than Woodbush and usually experiences at least one month without rainfalls. During this period (usually July) the moss becomes dry and brittle but greens up and starts growing during August at Woodbush. There is a great fluctuation in the amount of rain from year to year, being in some years two to three times as much as in other years (Table 6). In these mountainous areas it often rains for days on end with as much as three weeks of cloudy rainy weather, while on the other hand thunderstorms of short duration but intense rainfall occur.

Evaluation of Results

The results reveal that the initial annual harvesting yielded 0,034 kg/square metre. This dropped radically (see Fig. 1) after the initial harvesting and the average annual growth of moss on the plots yielded 0,002 kg/sq. metre (7,6 %). In contrast the biennial plots yielded 0,11 kg/sq. m on the initial harvest, but two years later only 0,017 kg/sq. metre (15,45%) had re-grown, which is just over twice the productivity of the annual plots. The triannual plots, which when first harvested yielded 0,029 kg/sq. metre, gave at the second harvest only 0,008 kg/sq. metre (27,5 %). This is 3,62 times as much as that of the annual plots and 1,77 times as much as the biennial plots calculated on a percentage basis. At this growth rate the moss would take a minimum of seven years to reach the initial amount harvested and may even take up to 10 years.

The layout of the experimental plots lends itself to statistical analysis by means of a randomised complete block design. The data from the annually harvested plots (1972, 1973 and 1974) were analysed separately from those harvested biennially (1972 and 1974) and triannually (1972 and 1975) (see Tables 7, 8 and 9).

TABLE 7.

Analysis of variance of moss weights (kg per 10×10 m plot) collected annually in 1972, 1973 and 1974.

Source of variation	Sum of squares	Degrees of freedom	Mean Square	F
Plots	0,008819	3	0,002940	2,63
Subplots	0,050897	36	0,001414	1,27
Years	0,046448	2	0,023224	20,81*
Error	0,006693	6	0,001116	
TOTAL	0,1222857	47		

*Significant at 1 % level.

TABLE 8.

Analysis of variance of moss weight (kg per 10×10 m plot) collected biennially in 1972 and 1974.

Source of variation	Sum of squares	Degrees of freedom	Mean Square	F
Plots	0,029397	4	0,0007349	1,20
Subplots	0,238244	30	0,007941	1,30
Years	0,197543	1	0,197543	32,25*
Error	0,024501	4	0,006125	
TOTAL	0,489685	39		

*Significant at 1 % level.

TABLE 9.

Analysis of variance of moss weight (grams per 10×10 m plot) collected triannually in 1972 and 1975.

Source of variation	Sum of squares	Degrees of freedom	Mean Square	F
Plots	325,0	4	81,25	0,78
Years	1 210,0	1	1 210,00	11,72*
Error	413,0	4	103,25	

*Significant at 5 % level.

The results were on the whole similar for the annually, biennially and triannually harvested plots. No significant variation was found to be due to the plots or the subdivisions within each plot, indicating that conditions within each plot and subplot were similar, such as the total surface area available for moss growth, moisture (partly) and temperature conditions, etc. However, very significant differences were found to be caused by the annual treatment, which were most likely due to variations in the way of harvesting of moss from year to year. For instance during 1972 the moss was harvested from the majority of trees within the plots. In 1973, however, many of the trees had moss of only very short length

(5 mm or less) which could not be harvested in standard fashion and was thus left until 1974 when it might be long enough for plucking.

Some influence is obviously due to the variation in the number of misty days per annum at Woodbush, as it has been shown that mist contributes significantly to the amount of moisture available to mosses.

It is interesting to note that increases or decreases in moisture and "treatment" do not seem to affect all plots to the same degree. Table 10 reflects the proportions of moss collected from each plot in 1972, 1973, 1974 and 1975 respectively considering plot C as unit. It will be noted that plot B produced 2,6 times as much in 1972, 2,3 times as much in 1973, 2,9 times as much in 1974 and only 1,0 times as much in 1975. This variation is also apparent in the other plots such as A where the production went from 1,9 times that of C in 1972 to 5,1 times as much in 1973 and dropped to 3,3 times in 1974 while it was only 1,3 times in 1975. It could here be noted that plot A is probably the most favourably situated plot of the set with regard to moisture and other aspects and therefore consistently shows a higher growth rate. Plot D situated in the most xeric situation also shows similar trends.

TABLE 10.

Comparison of proportions of moss produced from each plot during successive years. Plot C taken as unit in all cases.

Plot	1972	1973	1974	1975
A	1,9	5,1	3,4	1,3
B	2,6	2,3	2,9	1,0
C	1,0	1,0	1,0	1,0
D	1,2	0,0	1,4	0,7

DISCUSSION AND CONCLUSION

The average annual growth of moss at Woodbush over the three years 1973, 1974 and 1975 is 47 grams per plot while that at Bloemfontein is 45 grams indicating that in spite of the differences in rainfall, climate and edaphic conditions, similar growth is achieved. This lends support to the view that mist is an important factor for the growth of moss. The average regrowth is 7,64 % per annum. The biennial plots show a regrowth of 15,45 % over the two periods which is slightly more than double that of the annually harvested plots. The triannually harvested plots produced 27,58 % of the initial harvest after three years which is slightly more than three and a half times as much as the annually harvested plots and about 1,75 times as much as the biennially harvested ones. The growth rate appears to accelerate over three years as an average rate of 8,99 % is achieved. It is difficult at this stage to extrapolate the further rate of growth but it is assumed that this rate will probably not be maintained. At the present rate it will take the moss a minimum of seven years and possibly as much as 10 years to regenerate fully. It is not known at what stage moss actually reaches maturity and when it would be

most productive to harvest. It may be that the moss after reaching a certain length slows down completely so that harvesting on a sustained yield basis may best be done at an earlier stage when the standing crop has reached optimum growth and will begin to slow down. This stage may already be reached at seven years after harvesting. It must, however, be emphasised once again that harvesting during the experiment was considerably more severe than that of the Bantu gatherers who take only what is readily available, leaving ample moss and thus probably speeding up the process of regeneration.

Based on the average amount of moss initially harvested from the plots, 340 kg could be harvested per hectare which when calculated to cover the 15 958,83 hectares amounts to an overall weight of 5 426 002 kg of moss. In order to manage the reaping of moss on a sustained yield basis over a period of seven years 2 279,83 hectares could be harvested giving 775 143 kg of moss per year. On a 10 year rotational basis 1 595,88 hectares could be harvested giving a sustained yield of 542 600 kg per year. While the present experiment only sampled the moss growing on the trees itself, mention should be made of the large amounts also found hanging from the branches of smaller trees, on dead logs and on rocks which contribute considerably to the standing crop of a hectare of forest. This is, however, not uniform and some patches of forest are devoid of this. In addition it appears that once the moss has been removed from dead or decaying wood no subsequent regrowth occurs apart from that left from the previous plucking. There is, therefore, at least initially considerably more moss than the above figures indicate. In conclusion it may be worthwhile to harvest a set of plots after a period of five years and again after seven years, which will then give a good indication of the rate of growth during these periods as well as determine the best time interval between harvesting. The moss itself, however, limits the interval between harvests and is, therefore, the main limiting factor.

ACKNOWLEDGEMENTS

The following people and institutions are thanked for their help and advice:

The Departments of Forestry, Bantu Administration and Development for their generous consent to work in the areas under their control.

Mr. P. W. De Wet Wessels for rainfall data from the farm Piesanghoek, Soutpansberg District, as well as for allowing the author to camp there.

Dr. S. M. Hirst for help and guidance in the continuation of this project.

REFERENCES

- JACOBSEN, N. H. G., 1974. *An investigation into the ecology and productivity of Epiphytic mosses*. (Progress report (1974)). T.P.A. Nature Conservation Division.
- JOOSTE, J. P., 1971. *Ondersoek na die ekologie en produktiwiteit van Epifitiese mosse*. Flora Navorsing: Projek T.N. 6/4/3/4. Afdeling Natuurbewaring T.P.A.
- WELLINGTON, J. H., 1955. *Southern Africa: A geographical Study*. Vol. 1. p. 260. London: Cambridge University Press.

TABLE 2.
Weights of moss per unit surface area from plots at woodbush

Plot No.	Wt. of moss per plot (kg)					No. of trees				Bole surface area (sq. m)				Wt. of moss/unit surface area in kg/sq. m				
	1970	1972	1973	1974	1975	1972	1973	1974	1975	1972	1973	1974	1975	1970	1972	1973	1974	1975
A	2.481	0.350	0.075	0.105	0.055	23	19	17	12	24.84	24.50	22.79	15.38	0.095	0.014	0.003	0.005	0.004
B	1.758	0.490	0.034	0.090	0.042	30	13	22	14	21.13	20.19	30.84	20.00	0.054	0.015	0.001	0.003	0.002
C	0.487	0.190	0.014	0.031	0.042	30	9	18	15	19.14	6.33	11.31	10.78	0.025	0.009	0.002	0.003	0.004
D	0.927	0.220	0.000	0.046	0.029	17	—	9	9	14.08	0.00	10.22	7.88	0.065	0.015	0.000	0.004	0.004
Ave.	1.339	0.313	0.031	0.068	0.042					22.55	12.76	18.79	13.49	0.059	0.013	0.001	0.004	0.003

TABLE 3.
Weights of moss per unit surface area from plots at Bloemfontein

Plot No.	Wt. of moss per plot (kg)					No. of trees				Bole surface area (sq. m)				Wt. of moss/unit surface area in kg/sq. m				
	1970	1972	1973	1974	1975	1972	1973	1974	1975	1972	1973	1974	1975	1971	1972	1973	1974	1975
A	0.415	1.250	0.042	0.160	0.170	25	15	21	16	29.17	24.73	28.16	15.59	0.014	0.043	0.001	0.006	0.010
B	0.284	0.430	0.006	0.035	0.020	27	1	21	11	22.53	1.80	19.54	9.57	0.013	0.019	0.003	0.002	0.002
C	0.139	0.570	0.000	0.073	0.041	35	0	10	8	24.38	0.00	11.40	7.31	0.007	0.023	0.000	0.006	0.006
D	0.307	0.220	0.004			23	1	—	—	17.08	2.40			0.019	0.013	0.001		
E	0.193	0.080	0.000	0.000	0.020	17	0	0	6	15.83	0.00	0.00	8.24	0.014	0.006	0.000	0.000	0.002
Ave.	0.268	0.510	0.010	0.067	0.063					21.79	5.79	14.78	10.13	0.021	0.001	0.001	0.003	0.005

TABLE 4a
Variations in weight of moss per unit surface area (kg/sq. m) within plots at Woodbush over the period July 1972—July 1975

Plot No.	Bole surface area (sq. m)					Annual plots										Wt. of moss/unit surface area in (kg/sq. m)					
						Wt. of moss (kg)					Number of trees										
1972	1973	1974	1975		1972	1973	1974	1975		1972	1973	1974	1975		Ave.	1972	1973	1974	Ave.	Ave.	
A(a).....	6.67	6.61	5.65	3.36		0.074	0.019	0.034	0.009		6	5	4	0.011			0.003	0.003	0.006	0.003	
(b).....	1.65	1.03	1.20	0.93		0.019	0.003	0.006	0.004		4	2	3	0.011			0.004	0.004	0.004	0.004	0.004
(c).....	12.86	13.09	12.38	9.21		0.215	0.031	0.046	0.025		10	8	7	0.016			0.002	0.002	0.004	0.003	
(d).....	3.66	3.77	3.56	1.78		0.041	0.023	0.019	0.018		4	4	3	0.011			0.006	0.006	0.005	0.010	
B(a).....	7.53	3.95	6.36	2.34		0.101	0.009	0.020	0.009		6	1	2	0.013			0.002	0.002	0.003	0.004	
(b).....	6.23	4.19	6.49	4.90		0.062	0.009	0.023	0.007		6	4	6	0.009			0.014	0.003	0.003	0.002	0.002
(c).....	8.43	5.55	8.66	7.52		0.101	0.007	0.025	0.012		7	4	6	0.012			0.001	0.001	0.003	0.002	
(d).....	9.94	6.50	9.32	6.14		0.223	0.010	0.023	0.013		12	4	8	0.022			0.001	0.001	0.002	0.002	
C(a).....	4.29	2.71	3.94	3.92		0.081	0.005	0.014	0.014		8	3	6	0.019			0.002	0.002	0.003	0.004	
(b).....	2.65	0.00	2.08	2.41		0.081	0.000	0.003	0.003		3	—	2	0.006			0.011	0.000	0.001	0.002	0.004
(c).....	9.03	2.20	2.78	2.53		0.051	0.008	0.010	0.011		11	3	5	0.006			0.003	0.003	0.003	0.004	
(d).....	3.17	1.42	2.51	1.92		0.038	0.002	0.005	0.013		8	3	6	0.012			0.001	0.001	0.002	0.006	
D(a).....	0.72	0.00	1.46	0.80		0.009	0.000	0.010	0.001		3	—	3	0.013			—	0.007	0.007	0.002	0.002
(b).....	3.76	0.00	0.81	1.64		0.048	0.000	0.002	0.006		6	6	1	0.013			0.014	0.004	0.003	0.003	0.004
(c).....	3.17	0.00	3.73			0.032	0.000	0.009			3	—	3	0.010			—	0.002	0.002	0.005	
(d).....	6.43	0.00	4.21			0.135	0.000	0.025			5	—	2	0.021			—	0.006	0.006	0.005	

TABLE 4b.
Variations in weight of moss per unit surface area (kg/sq. m) within plots at Woodbush over the period July 1972—July 1974—Biennial plots

Plot No.	Bole surface area (sq. m)		Wt. of moss (kg)		Number of trees		Wt. of moss/unit surface area in kg/sq. m			
	1972	1974	1972	1974	1972	1974	1972	1974	Average	
									1972	1974
A1(a)	6.91	5.77	0.228	0.024	8	3	0.033	0.004	0.03	0.004
	9.83	4.94	0.470	0.021	7	3	0.048	0.004		
	10.36	9.98	0.213	0.041	10	8	0.021	0.004		
	3.89	3.17	0.115	0.008	9	5	0.029	0.003		
B1(a)	21.76	19.94	0.444	0.050	27	18	0.020	0.002	0.01	0.002
	0.69	—	0.004	—	3	—	0.006	—		
	5.82	0.48	0.072	0.002	5	1	0.012	0.004		
	4.60	1.44	0.043	0.003	9	2	0.009	0.002		
C1(a)	6.23	6.12	0.192	0.040	6	5	0.031	0.006		
	3.76	2.89	0.117	0.029	9	5	0.031	0.010	0.03	0.007
	2.28	1.69	0.067	0.007	6	3	0.029	0.004		
	1.75	0.94	0.039	0.005	7	3	0.023	0.005		
E1(a)	3.81	1.27	0.097	0.005	8	2	0.025	0.004		
	7.93	5.33	0.178	0.021	12	3	0.022	0.004	0.03	0.004
	4.58	2.62	0.082	0.006	8	4	0.018	0.002		
	4.72	3.07	0.196	0.017	4	2	0.042	0.005		
F1(a)	4.74	3.64	0.153	0.018	8	3	0.032	0.005	0.04	0.005
	1.05	1.13	0.046	0.005	7	3	0.044	0.004		
	6.56	4.08	0.233	0.023	13	6	0.036	0.005		
	3.65	3.74	0.170	0.023	10	4	0.046	0.006		

TABLE 4c.
Variations in weight of moss per unit surface area (kg/sq. m) within plots at woodbush over the period July 1972—July 1975—Tri-annual plots

Plot No.	Bole surface area (sq. m)		Wt. of moss (kg)		Number of trees		Wt. of moss/unit surface area in kg/sq. m			
	1962	1975	1972	1975	1972	1975	1972	1975	Average	
									1972	1975
A2(a)	5.91	3.43	0.164	0.026	8	5	0.028	0.007		
(b)	3.14	2.63	0.056	0.017	4	2	0.018	0.006		
(c)	6.47	6.10	0.202	0.029	10	8	0.031	0.005	0.026	0.006
(d)	5.27	1.86	0.113	0.017	8	5	0.021	0.009		
B2(a)	6.81	5.13	0.096	0.022	13	7	0.014	0.004		
(b)	7.11	4.25	0.172	0.011	16	5	0.024	0.003	0.023	0.005
(c)	0.66	4.70	0.003	0.033	3	3	0.005	0.007		
(d)	5.27	0.67	0.189	0.012	6	2	0.035	0.018		
C2(a)	2.05	1.89	0.119	0.029	6	5	0.058	0.160		
(b)	6.44	5.61	0.052	0.043	8	4	0.008	0.008		
(c)	0.97	0.56	0.150	0.011	3	2	0.015	0.019	0.027	0.014
(d)	6.06	5.12	0.238	0.099	4	3	0.039	0.019		
E2(a)	7.72	3.13	0.134	0.019	13	3	0.017	0.006		
(b)	3.18	2.43	0.172	0.035	4	2	0.054	0.014	0.021	0.009
(c)	0.21	—	0.000	0.000	1	—	—	—		
(d)	6.98	1.87	0.068	0.013	7	2	0.009	0.007		
F2(a)	2.27	2.51	0.161	0.017	7	6	0.071	0.007		
(b)	1.25	3.69	0.092	0.030	7	3	0.074	0.008	0.053	0.006
(c)	4.63	1.35	0.316	0.006	3	1	0.068	0.004		
(d)	10.11	7.08	0.399	0.037	18	7	0.039	0.005		

TABLE 6.
Rainfall in millimetres over the past seven years for experimental areas Broederstroom

Month	1969	1970	1971	1972	1973	1974	1975	Average
January	362.3	129.4	428.1	860.8	121.8	620.9	314.9	405.5
February	125.3	122.1	209.9	639.5	182.0	700.0	599.5	368.3
March	434.3	31.7	42.5	519.8	228.3	256.6	204.1	245.3
April	104.0	24.1	152.8	78.5	233.6	143.1	127.5	123.4
May	42.4	64.0	33.8	72.1	6.6	6.3	33.0	36.9
June	16.0	19.0	7.5	6.5	40.1	0.0	41.5	18.7
July	3.0	45.5	0.0	18.0	38.8	37.5	1.5	20.6
August	12.5	8.3	4.7	14.0	11.0	8.5	31.0	12.9
September	42.5	36.1	40.0	14.6	152.5	97.0	20.5	57.6
October	228.3	96.3	177.8	110.2	206.9	52.6	37.3	129.9
November	75.6	93.0	228.5	139.8	164.5	231.5	97.0	147.1
December	188.4	225.3	175.3	223.6	554.2	205.0	407.6	282.7
Total	1624.8	894.8	1500.9	2697.4	1940.0	2359.0	1915.4	1848.9

TABLE 6.
Rainfall in millimetres over the past seven years for experimental areas Louis Trichardt

Month	1969	1970	1971	1972	1973	1974	1975	Average
January	51.2	0.0	181.1	193.3	72.3	259.7	165.8	131.9
February	57.9	89.6	30.9	154.9	103.0	259.5	248.3	134.9
March	248.6	23.7	24.8	135.8	62.4	15.1	58.2	81.2
April	31.7	0.0	45.1	12.0	58.0	51.5	69.4	38.2
May	19.7	13.5	43.5	32.9	3.5	38.6	29.2	25.8
June	4.9	16.5	4.1	2.0	15.2	0.0	19.8	8.9
July	0.0	7.0	0.0	0.0	16.7	8.1	0.0	4.5
August	0.0	0.0	0.0	6.2	0.0	0.0	5.5	1.7
September	44.4	3.9	15.6	2.0	144.2	78.6	0.0	41.2
October	57.6	59.6	85.5	173.7	113.6	2.3	11.5	71.9
November	37.5	45.3	207.1	105.4	43.8	165.4	67.0	95.9
December	115.9	167.0	60.3	41.2	147.9	92.6	132.6	108.2
Total	669.4	426.2	689.0	859.4	780.6	919.9	807.3	744.3

BOOK REVIEWS

DORMANCY AND THE SURVIVAL OF PLANTS, by Trevor A. Villiers. Studies in Biology No. 57. London, Edward Arnold, 1975. 68 pp. Price £2,80 (hard cover).

This book, written by an acknowledged expert in the field of dormancy, covers ten short chapters, dealing with: the dormant state; climate and survival; structural modifications in dormancy; resistance of dormant organisms; control of entry into dormancy; types of seed dormancy; metabolism during dormancy; biochemical controls and dormancy; emergence from dormancy; and conclusions.

As the chapter headings indicate, just about every facet of dormancy worth considering is discussed. This is done in an easily readable style, well illustrated with graphs, tables, line drawings and schematic representations. As a well-balanced introduction to the subject it can hardly be improved upon (bearing in mind, of course, the space restrictions applicable to a book in this series). Particular attention is given to the role of hormones in the induction, maintenance and termination of dormancy, in conjunction with the environmental "triggers" involved, but I think that the views of Vegis in this regard could have received some more attention, even in a book at this level.

This book is clearly not intended for specialists on the subject of dormancy, but even they can benefit from its reading. It can be highly recommended for undergraduate students in plant physiology and horticulture, and should make very useful reading for all botanists and plant scientists in general.

J. A. DE BRUYN

COMPOSITAE IN NATAL, by O. M. Hilliard, with pp. xi+659 incl. 25 pp. line drawings. Pietermaritzburg: University of Natal Press, 1977. R24,00. (Orders to: University of Natal Press, P.O. Box 375, 3200 Pietermaritzburg, South Africa. American and Canadian orders to: Laurence Verry, Inc., Mystic, Connecticut 06355, U.S.A.).

More than a century has elapsed since the appearance of Harvey's classical treatment of the Compositae in *Flora Capensis*. Perhaps another century will have gone before the ambitious, new *Flora of Southern Africa* is finished. Under these circumstances a modern regional account of a large family is most welcome. Dr O. M. Hilliard's *Compositae in Natal* must be added to the list of standard works on the South African flora. The present volume also paves the way for the complete treatment of the family in the new flora.

As someone who has studied the South African Compositae, particularly in Natal, for a long time now, Dr Hilliard was certainly the right person to undertake such a comprehensive task. During many years of field work she has discovered numerous undescribed species and many new records for Natal. Moreover, she has critically revised the material in herbaria both at home and overseas, a most laborious task. Part of the original research which preceded this volume has been published in a series of joint papers with B. L. Burt (see: Notes Roy. Bot. Gard. Edinb., 1970—).

Not surprisingly, the Compositae is the largest family of flowering plants found in Natal province. The present account deals with no fewer than 640 species, belonging to 113 genera. They include constituents of most of the vegetation types present in the province, covering a wide range of habitats from littoral scrub to the alpine heaths of the highest mountains in South Africa. Weeds and aliens are also covered, with notes on their origins and other useful information. The text provides determination keys, full generic and specific descriptions, notes on geographical distribution, ecology and flowering times, and frequent

taxonomic comments, e.g. on infraspecific variation and nomenclature. Although the generic descriptions are modelled on those of Bentham, the sequence adopted is that of Dalla Torre and Harms. The precise and accurate specific descriptions are all original. All types seen by the author are fully cited and the relevant synonyms given, also with types.

The primary aim of the book is to aid accurate identification, for which purpose good alternative keys are given. There is a general key to all genera, but one can also proceed via the key to the tribes followed by the generic keys for each tribe. There are also keys down to species level for all genera which include more than one species.

The classical 13 tribes are recognized and all are represented, although in some cases only by introduced species (*Heliantheae*, *Helenieae*, *Cardueae*). The author is well aware of the current conflict of opinions on tribal circumscription, but she has wisely adopted a conservative taxonomic frame-work.

The line drawings are both accurate and artistically appealing, and more would have been very welcome. A useful feature is the introductory series of drawings, explaining the niceties of synantherological terminology. On the inside covers of the strongly cloth-bound volume are two survey maps. A comprehensive index to all taxa, including synonyms, completes the text. Relevant bibliographical references are given in the headings to genera and species, sometimes also in the commentaries.

This important publication is obviously indispensable to all students of South African Compositae, but will also be of great interest to taxonomists and phytogeographers in general. Ecologists, agriculturists, gardeners and biology teachers will also find much useful information in this book, which will undoubtedly attract considerable attention far outside South Africa itself.

BERTIL NORDENSTAM

WOOD STRUCTURE IN BIOLOGICAL AND TECHNOLOGICAL RESEARCH, edited by P. Baas, A. J. Bolton and D. M. Catling, with pp. 280, 28 fig., 25 plates. (Leiden Botanical Series No. 3.) ISBN 90 6021 302 5. Leiden University Press, 1976. (approx. R28,00).

Despite its title, this is a collection of studies in plant anatomy. It arose from the proceedings of the Anglo-Dutch Wood Anatomy Meeting, organised by the Royal Microscopical Society at Oxford and Kew in April 1976. Appropriately it opens with an entertaining essay on the history of the Jodrell Laboratory, with whose centenary this meeting coincided. The former Keeper, C. R. Metcalfe tells of the personalities and events that led to the establishment of what might be called the English School of systematic anatomy, at Kew. A useful survey by J. D. Brazier deals in general terms with the use of wood anatomical features in identification and in taxonomy, both of which present their own peculiar problems. This is well shown in the two detailed papers which follow. T. Baretta-Kuipers discusses the taxonomic position of the genera, and the relationship between the families in the *Bonnetiaceae*, *Theaceae* and *Guttiferae*, and G. van Vliet the identification and systematic and phylogenetic relationships within the *Rhizophoraceae*. R. den Outer and W. van Veenendaal investigate the effects of the rainforest and savanna environment (in West Africa) on within-species wood anatomical characters and try to distinguish them from the effects of phylogenetic drift. A short paper contributed by D. F. Cutler deals with a little-known field, variability of root wood structure and its comparison with trunk wood.

There have been many publications in recent years which deal with the distribution of siliceous inclusions and their value in taxonomy. In the present volume Ben ter Wille gives a comprehensive survey of the occurrence of silica in neotropical woods and concludes that it has considerable diagnostic value, especially at the species level. Probably the most interesting and significant contribution in this book is that of P. Baas, on xylem vessel variation in relation to environment and evolution. He gives a careful and well documented critique of Carlquist's theory of adaptive diversification, for which he finds rather limited evidence.

The book includes some interesting chapters on more general topics, such as aspects of branch abscission (J. Koek-Noorman and B. ter Welle), a somewhat neglected subject, and the examination of a theoretical model for liquid flow through tracheids and pits (A. J. Bolton). The cambial production of wood in relation to apical meristem activity is explored by M. P. Denne, and the origins of short term tracheid variation by E. D. Ford and A. W. Robards. Only three papers are of essentially technological interest, two dealing with structural failure and one with plastic impregnation, in relation to wood microstructure.

This book is exceptionally well produced. There is an attractive layout and good reproduction of the line drawings and photomicrographs. A particularly valuable feature is the adequate lists of references, to literature much of which may not be familiar to every botanist.

A. R. A. NOEL

Preliminary Announcement

THIRTEENTH INTERNATIONAL BOTANICAL CONGRESS

Sydney, Australia. 21–28th August, 1981

The Programme will consist of 12 sections—molecular, metabolic, cellular and structural, developmental, environmental, community, genetic, systematic and evolutionary, fungal, aquatic, historical, and applied botany. There will be plenary sessions, symposia, and sessions for submitted contributions (papers and posters). Chairman of the Programme Committee: Dr L. T. Evans.

Field Trips will include visits to arid and semi-arid regions, eucalypt forest, rain forest, heath, coastal vegetation (e.g. Great Barrier Reef, mangroves) etc., and specialist trips. Chairman of the Field Trips Committee: Prof. L. D. Pryor.

First Circular, containing details, will be mailed in August, 1979. Send your name and full address, preferably on a postcard, to ensure your inclusion on the mailing list.

Enquiries should be sent to the Executive Secretary, Dr W. J. Cram.

Congress address—13th I.B.C., University of Sydney, N.S.W. 2006, Australia.

Sponsored by the Australian Academy of Science



THE VASCULAR ANATOMY OF THE SEEDLING OF *ENCEPHALARTOS EUGENE-MARAISII* VERDOORN

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(Department of Botany, University of Pretoria)

ABSTRACT

The path of the vascular strands in the seedling of *Encephalartos eugene-maraisii*, from the primary root to the cotyledons and first vegetative leaves is discussed. Each of the two cotyledons is supplied with three leaf traces while the first vegetative leaf is supplied with four vascular bundles originating from a girdle in the vascular plate. The primary xylem in the leaf base is mesarch, becoming endarch towards the first pinna.

UITTREKSEL

DIE VAATANATOMIE VAN *ENCEPHALARTOS EUGENE-MARAISII* VERDOORN SAAILINGE

Die ligging van die vaatbundels in die *Encephalartos eugene-maraisii* saailinge word vanaf die primêre wortelpunt tot by die saadlobbe en eerste vegetatiewe blare bespreek. Elk van die twee saadlobbe is voorsien van drie blaarvaatstringe terwyl die eerste vegetatiewe blare van vier vaatstringe wat uit 'n gordel in die vaatplaat ontstaan. Die primêre xileem in die blaarbasis is mesarg en word endarg in die rigting van die eerste pinna.

INTRODUCTION

The Cycadales is a very interesting plant group and it is not surprising that by the end of the 19th century a considerable amount of literature had been built up on a variety of morphological aspects of this taxon. Very little, however, has been done on the South African *Encephalartos* species and therefore a morphological study of *E. eugene-maraisii* was started by van der Westhuizen (1976). During this study it became clear that there was still doubt as to the origin of the centrifugal xylem in the petiole of the Cycads in spite of Le Goc's (1914) paper which dealt with this problem. There was also doubt about the number of vascular strands entering the cotyledons of seedlings of *Encephalartos* species since Matte, according to Dorety (1908), described the anatomy of *E. barteri* with three cotyledons (probably an abnormal seedling), each with only one trace.

This study was undertaken to contribute to the knowledge of the anatomy of the Cycadales and to try to supply answers to the above-mentioned problems.

MATERIAL AND METHODS

Two-month-old seedlings of *Encephalartos eugene-maraisii* and of *E. trans-venosus* were obtained from the Division of Nature Conservation, Transvaal

Provincial Administration. One seedling was transversely sectioned at the positions indicated in Fig. 1. Diagrams of the sections are shown in Fig. 2A–S. Serial microtome sections, 8–10 μm thick, were made of one other seedling and hand sections were made of two other seedlings. Standard procedures for embedding, sectioning and staining were followed to obtain serial sections (Johansen, 1940).

RESULTS AND DISCUSSION

At the seedling stage depicted in Fig. 1, one vegetative leaf has developed while the greater part of the two cotyledons is still embedded in the female gametophyte tissue which is enveloped by the seed coat. The proximal end of the primary root is tuberous, and a few young apogeotropic roots have developed (not shown in figure).

At levels A and B (Figs 1 and 2) the roots of some seedlings are octarch while others are tri- or tetrarch. In the root from which the sections A–S were prepared no endodermis was distinguishable although it was well-developed below this point in all the roots examined. The pith is well-developed and its diameter increases in the tuberous part of the root, due to irregular divisions of cells of the ground tissue, resulting in the displacement of the primary xylem and phloem groups (Fig. 2B–D). This primary thickening growth also takes place in the cortex.

The primary xylem groups consist of relatively small protoxylem elements and large metaxylem elements which give the impression of transfusion tissue. These metaxylem elements do not only differentiate in a centripetal direction, but also in a lateral and centrifugal direction to form arcs radiating from the protoxylem. Worsdell (1897) also commented on the extension of the centripetal xylem towards the sides of the bundle in the cotyledonary bundles of *Cycas* and *Ginkgo*, in his attempts to determine the origin of the transfusion tissue in Gymnosperm leaves.

The later-formed metaxylem elements at first lie in direct contact with the other metaxylem elements but can at a later stage become separated from them by the intrusion and divisions of the pith parenchyma cells (Fig. 5A).

In the seedling with the octarch root (Fig. 2A) xylem strands 1 and 7 dichotomise at levels C and D respectively, but branch 1a disappears again at level D and branch 7a disappears at level E. At level F, branches 1b and 7b fuse while 3 and 6 disappear so that at the lower end of the hypocotyl at level G only branches 2, 4, 5 and 7b remain.

In tetrarch roots, the primary xylem strands remain unchanged up to level G, while in the case of a triarch root, one of the xylem strands dichotomises to form a tetrarch stele in the hypocotyl. Pearson (1898) describes a reduction of the pentarch structure to a triarch in *Bowenia* while Dorey (1919), in her description of the seedling of *Dioon spinulosum*, states that "the vascular cylinder of the hypocotyl is a protostele; it has four easily recognized protoxylem groups, in no way differing from the hypocotyl cylinders of *Ceratozamia* and *Microcycas*".

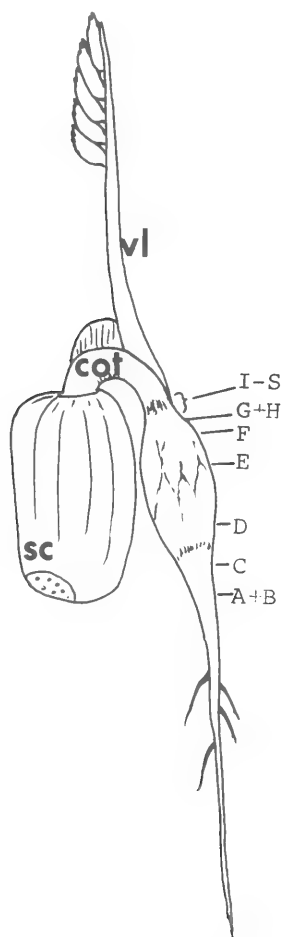


FIG. 1.

Young seedling of *Encephalartos eugene-maraisii* showing levels A-B where sections were made. cot—cotyledon; sc—seed coat; vl—vegetative leaf.

About the seedling of *Dioon edule*, Thiessen (1908) states that at each corner of the squarish vascular plate there is a group of protoxylem elements. In *E. transvenosus* the vascular cylinder is pseudotetrarch. It seems, therefore, that regardless of the number of protoxylem strands in the roots of most of the Cycad

seedlings investigated, the hypocotyl is tetrarch or triarch. The triarch condition in *Bowenia* will have to be re-investigated as the condition in *E. eugene-maraisii* at level H (Fig. 2), which resembles that in *Bowenia* to a certain extent, could be misinterpreted as triarch.

The hypocotyl is very short and stretches only from levels G to about K, a length of approximately one millimeter. This is in agreement with what has been found in other Cycad seedlings.

Each of the two cotyledons is supplied with three leaf traces. Traces a, b and c (Fig. 2L) enter the one cotyledon while traces d, e and f (Fig. 2M) enter the second (see also Fig. 3). The central traces b and e remain unbranched while the lateral traces c, d and f dichotomise and a splits up into three branches (Fig. 2L-O). In the other seedlings of *E. eugene-maraisii* investigated, trace a splits up into two branches.

Three leaf traces (strands) were also found in *Cycas revoluta* (Worsdell, 1898), *Cycas siamensis* (Matte, 1904), *Ceratozamia* (Dorety, 1908), *Macrozamia spiralis* (Worsdell, 1898) and *Stangeria paradoxa* (Worsdell, 1898) while in *Dioon edule* (Thiessen, 1908) and *Dioon spinulosum* (Dorety, 1919) two leaf traces are given off to each cotyledon but, before entering the cotyledons, they branch so that four vascular strands enter each cotyledon. In *Zamia muricata* (Karsten, 1856) and *Bowenia spectabilis* (Pearson, 1898) only one leaf trace per cotyledon is given off but it also branches so that each cotyledon is supplied by four vascular strands. According to Coulter & Chamberlain (1910) the condition in *Dioon* is characteristic of the Cycads but from the cited examples it is clear that the three leaf traces per cotyledon as described in this paper for *Encephalartos* is more common among the Cycads. It would seem, therefore, that the seedling of *E. barkeri* with three cotyledons which was described by Matte (1904) must have been abnormal. Three leaf traces were also found in a seedling of *E. transvenosus* which was studied as a comparison with seedlings of *E. eugene-maraisii* (Fig. 4).

In his description of the seedlings of *Cycas revoluta*, *Macrozamia spiralis* and *Stangeria paradoxa*, Worsdell (1898) mentioned three peculiar strands leaving the stele in the hypocotyl and extending "perpendicularly" in the cortical tissue. He could not decide whether they were strands of roots or not. In this study similar strands were observed but they were definitely the strands of the so-called apogeotropical roots which later dichotomised to form coralloid roots (Fig. 4, see also Fig. 5D for gaps where these strands leave the central cylinder).

Four vascular bundles enter the first vegetative leaf at two different levels. Bundles h and i which remain unbranched, have their origin at level O (Fig. 2). Both are compound bundles receiving traces from a common vascular arc between two of the original vascular strands of the hypocotyl. Bundles g and j originate at level M on the side of the leaf base opposite to the root poles 2 and 4 (Fig. 3) forming a girdle around the vascular plate. The bundles g and j each divide into four bundles which enter the leaf base at levels P and Q (Fig. 2C). The first

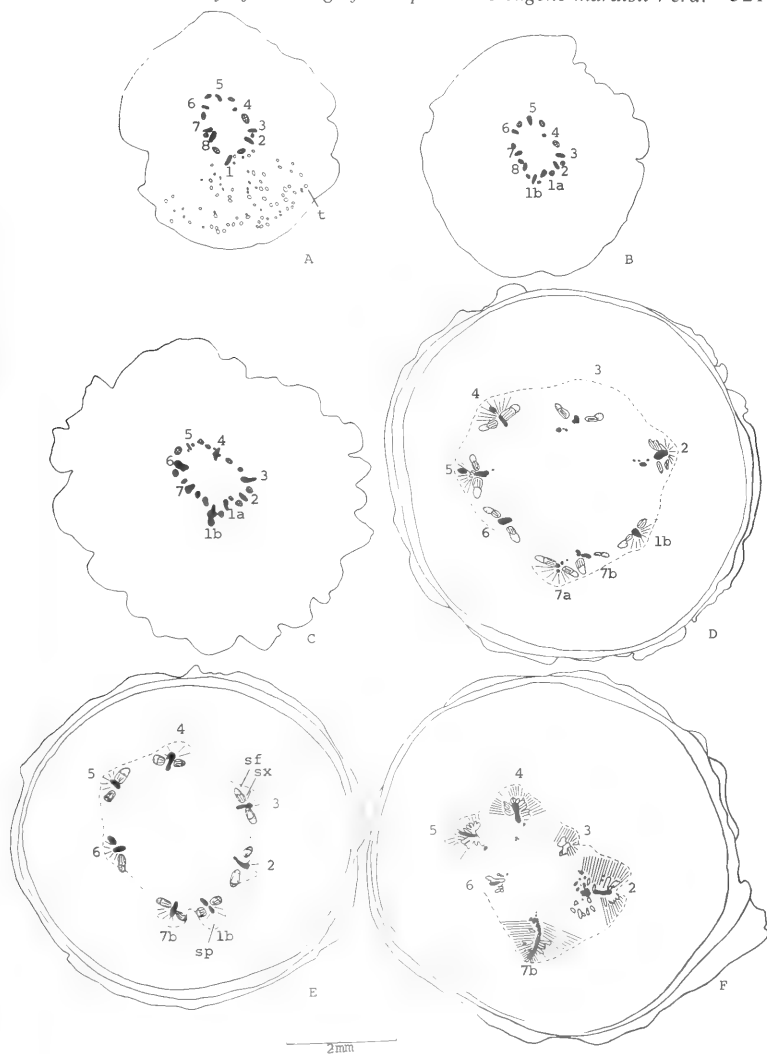


FIG. 2

Serial transverse sections through a seedling of *E. eugene-maraisii* at levels indicated in Fig. 1. 1-8: primary xylem groups in root and hypocotyl. a-f: vascular strands supplying the cotyledons. g-j: vascular strands supplying the first vegetative leaf. am—apical meristem; cot 1 and cot 2—basis of cotyledons; per—periderm; sd—slime ducts; sf—secondary phloem; sp—secondary parenchyma; sx—secondary xylem; t—tanniferous cells; vpl—vascular plate; 1stl—first vegetative leaf; 2ndl—second vegetative leaf.

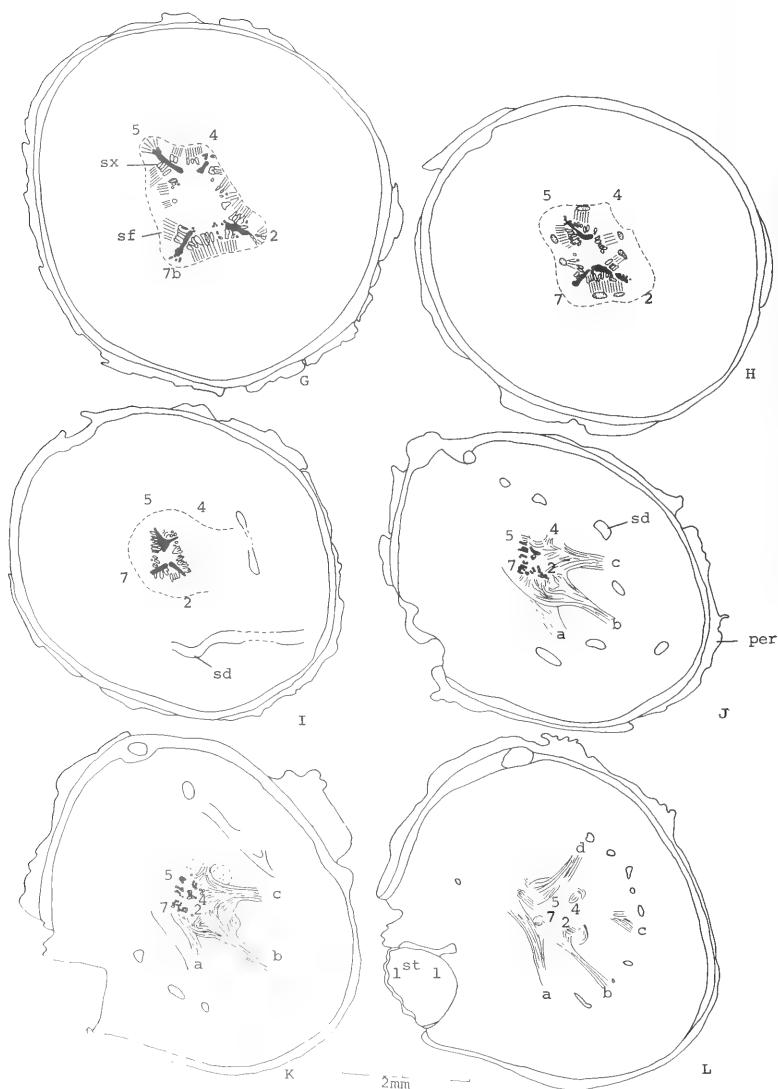


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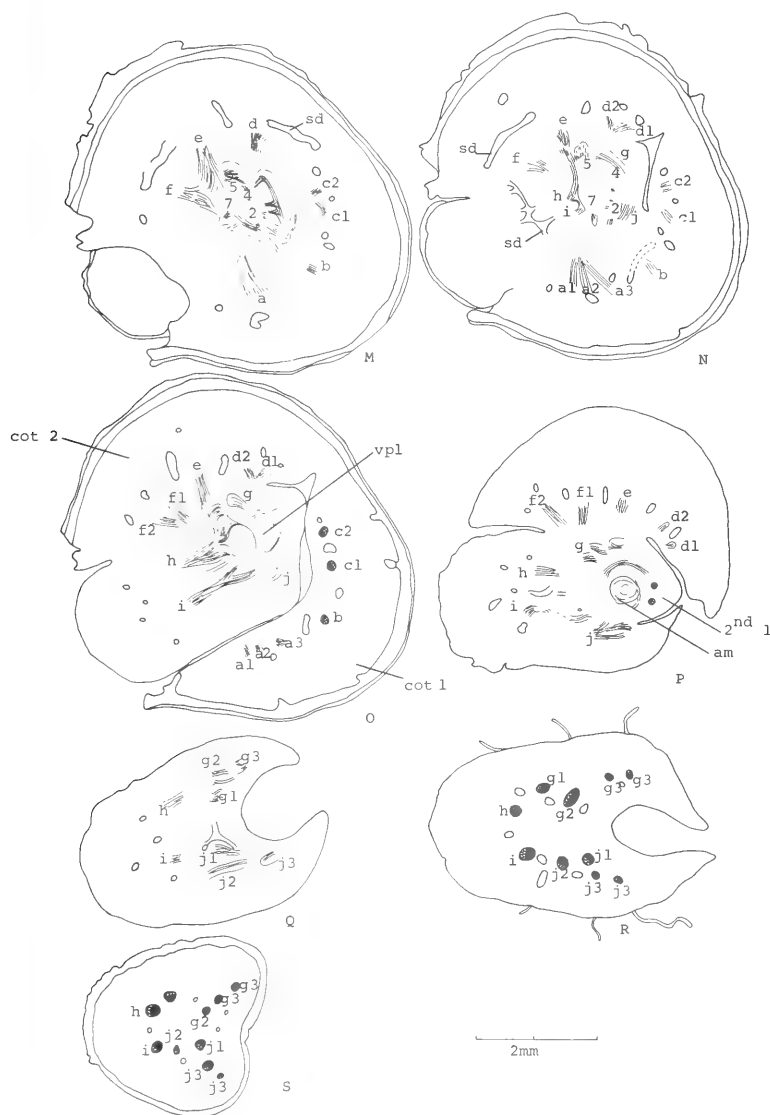


FIG. 2

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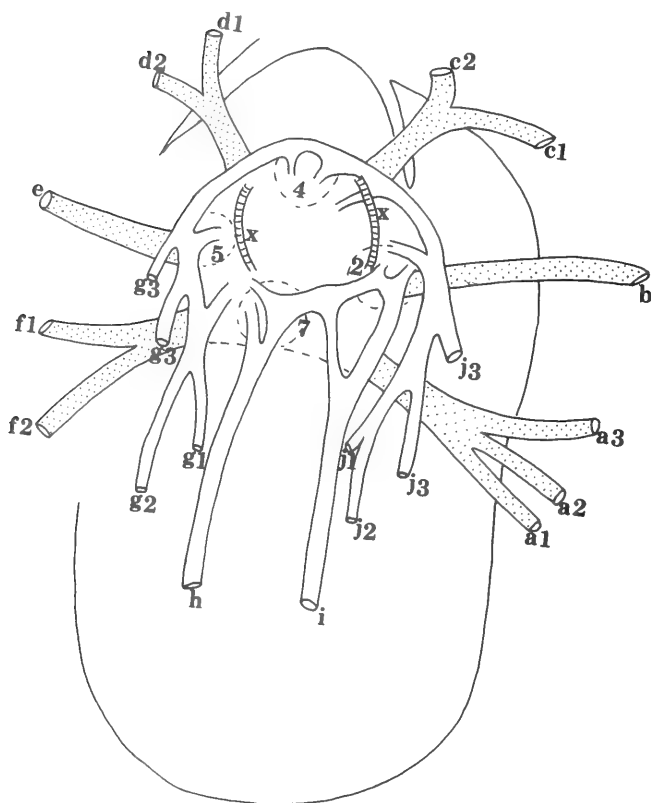


FIG. 3.

Reconstruction of sections A-S in Fig. 2 to illustrate the vasculature in the seedling of *E. eugene-maraisii*. 2, 4, 5 & 7: vascular groups of tetrarch stele. a-f: vascular strands supplying the cotyledons. g-j: vascular strands supplying the first vegetative leaf. x: girdle of vascular tissue supplying the 2nd vegetative leaf.

vegetative leaf thus has a total of ten vascular strands in its base (Fig. 2CR). In *E. transvenosus* (Fig. 4) the same basic pattern is followed.

In his description of the vascular anatomy of the seedling of *Dioon edule*, Thiessen (1908) found four vascular bundles entering the first vegetative leaf. A similar condition occurs in *E. eugene-maraisii* with the exception that in *E. eugene-maraisii* the first two bundles are compound, whereas in *Dioon* they are not. Dorety (1908) also found a similar four-bundle pattern in *Ceratozamia*.

Secondary growth in the root commences when cambium segments are

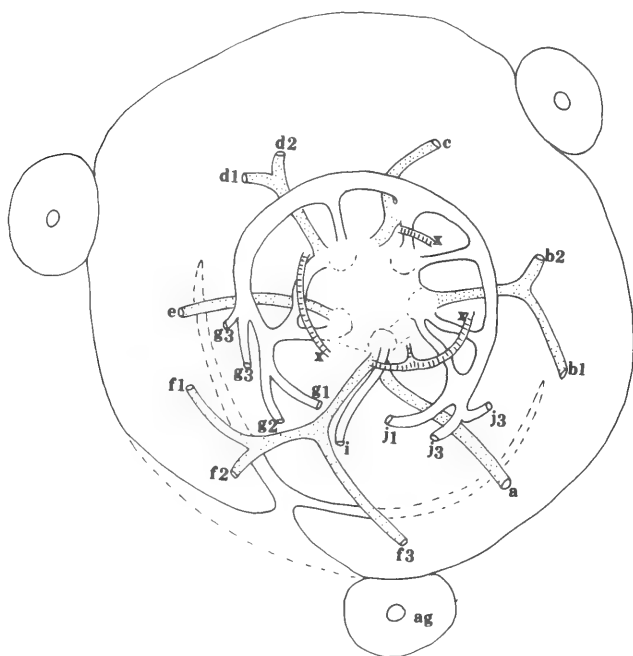


FIG. 4.

Reconstruction of the vasculature in the seedling of *E. transvenosus*. Figures and numbers as for Fig. 3. ag—apogeotropic roots.

differentiated on either side of each radiating primary xylem strand, thus forming secondary tracheids and sieve cells in a more or less tangential direction (Figs 2F and 5C). Because secondary tracheids are about the same size and have the same staining qualities as the metaxylem elements, it is very difficult to differentiate between them. Opposite the protoxylem, a few secondary tracheids may be formed although most of the secondary tissue at this point consists of secondary parenchyma, in broad medullary rays (Fig. 5B).

Le Goc (1914) pointed out that the parenchymatous band between the protoxylem and centrifugal xylem in the petiole of Cycadales is an indication that the centrifugal xylem is of secondary origin. In this study, however, it has been found that even in the root, the metaxylem elements are often separated from the protoxylem by the intrusion of parenchyma cells as a result of primary thickening growth of the tuberous roots (Fig. 5A). The presence of the parenchymatous band, therefore does not provide sufficient evidence for making deductions as to the origin of the centrifugal xylem.

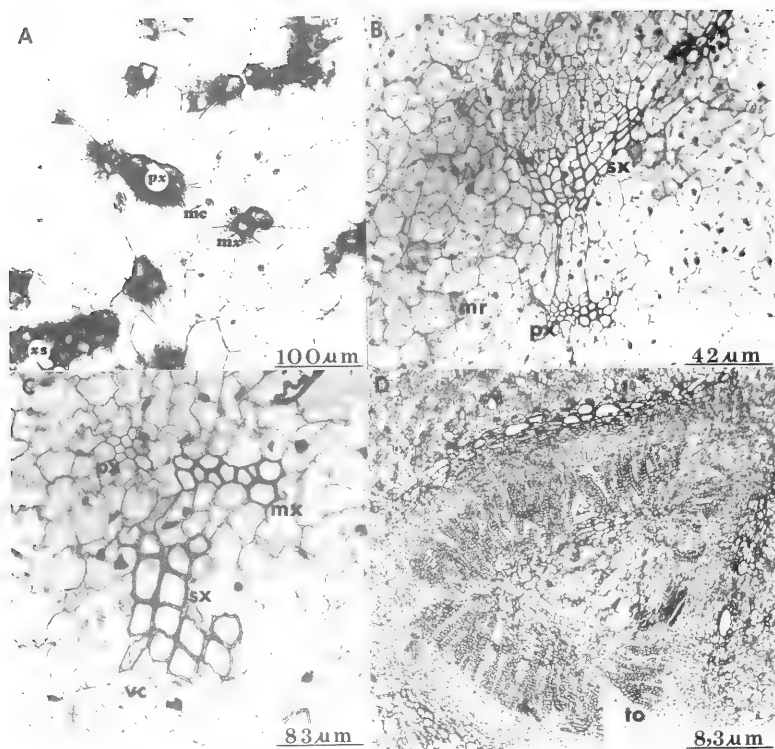


FIG. 5.

Transverse sections at different levels of the seedling of *E. eugene-maraisii*. A at level B in Fig. 2; B at level F in Fig. 2; C at level D in Fig. 2; D from another seedling at level H. mc—meristematic cortical cell; mr—medullary ray parenchyma; mx—metaxylem tracheids; px—protoxylem; sx and xs—secondary xylem tracheids; to—trace gaps for apogeotropical roots; vc—vascular cambium.

When the differentiation of xylem elements from the procambium strands in the first vegetative leaf is followed acropetally from the leaf base into the petiole, it is clear that the position of the protoxylem in the procambium strand in these two regions differs. In the leaf base the first protoxylem elements differentiate near the centre of the procambium strand (Fig. 6A), while the metaxylem elements differentiate centrifugally as well as centripetally, thus giving rise to mesarch xylem (Fig. 6C). Acropetally the first protoxylem elements are gradually displaced centrifugally so that less centrifugal and more centripetal xylem is formed until, near the first pinna, no centrifugal xylem differentiates at all, thus giving rise to

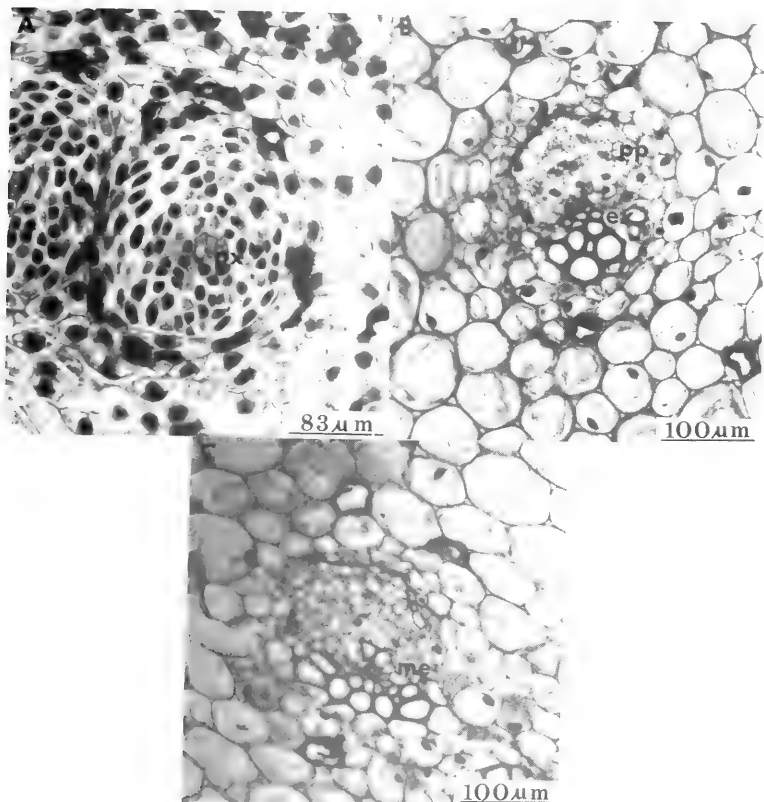


FIG. 6

Segments of transverse sections of the young petiole of *E. eugene-maraisii* to show A—procambium strand with first protoxylem elements in the leaf base; B—exarch xylem near first pinna; C—mesarch xylem in middle of petiole. px—protoxylem elements; pp—primary phloem; ex—exarch xylem group; me—mesarch xylem group.

exarch xylem (Fig. 6B). After secondary thickening growth has commenced, therefore, the centrifugal xylem in the leaf base would consist of metaxylem and secondary xylem whereas in the distal end of the petiole it would consist purely of secondary xylem.

Le Goc (1914) stated that "... the centripetal xylem is an independent tissue, probably the remnant of an ancient and more developed structure". He also stated that the centripetal and centrifugal xylem "... are continuous physiologically but not morphologically", probably having the parenchyma cells between the protoxy-

lem and the centrifugal xylem in mind. If this was true it would mean the centrifugal xylem would consist only of metaxylem and it would be hard to believe that it could be an "independent tissue".

It is therefore concluded that:

1. The primary centripetal and centrifugal xylem has a common group of protoxylem elements and therefore cannot be regarded as independent tissues. Instead it is found in vascular bundles with mesarch primary xylem.
2. Before secondary growth has commenced, the centrifugal xylem consists only of metaxylem elements but it can be supplemented by secondary xylem once secondary thickening growth has taken place.

ACKNOWLEDGEMENTS

This research was sponsored by the Division of Nature Conservation of the Transvaal Provincial Administration and the University of Pretoria. Thanks are due to Mrs J. E. Lombard for reading the manuscript.

REFERENCES

- COULTER, J. M. and CHAMBERLAIN, C. J., 1910. *Morphology of the Gymnosperms*. Chicago: University of Chicago Press.
- DORETY, H. A., 1908. The seedling of *Ceratozamia*. *Bot. Gaz.* **46**: 203-220.
- DORETY, H. A., 1919. Embryo and seedling of *Dioon spinulosum*. *Bot. Gaz.* **67**: 251-257.
- JOHANSEN, D. A., 1940. *Plant microtechnique*. New York: McGraw-Hill.
- KARSTEN, G., 1856. Organographische Betrachtung der *Zamia muricata* Willd. *Abh. Kgl. Akad. Wiss. Berlin.* 193-219.
- LE GOC, M. J., 1914. Observations on the centripetal and centrifugal xylems in petioles of cycads. *Ann. Bot.* **28**: 184-193.
- MATTE, H., 1904. *Recherches sur l'appareil libéro-ligneux des Cycadacées*. Caen.
- PEARSON, H. H. W., 1898. Anatomy of the seedling of *Bowenia spectabilis* Hook. f. *Ann. Bot.* **12**: 475-490.
- THIESSEN, R., 1908. The vascular anatomy of the seedling of *Dioon edule*. *Bot. Gaz.* **46**: 357-380.
- VAN DER WESTHUIZEN, S., 1976. 'n Morfologiese studie van *Encephalartos eugene-maraisii* Verdoorn. M.Sc. thesis. Pretoria: University of Pretoria.
- WORSDELL, W. C., 1897. On the origin of transfusion tissue in leaves of Gymnospermous plants. *J. Linn. Soc.* **33**: 118-122.
- WORSDELL, W. C., 1898. Comparative anatomy of the Cycadaceae. *J. Linn. Soc.* **33**: 437-457.

STUDIES IN THE GENERA OF THE DIOSMEAE (RUTACEAE): 7.

ION WILLIAMS

(Honorary Reader, Bolus Herbarium, University of Cape Town
Honorary Research Worker, Compton Herbarium, Kirstenbosch)

ABSTRACT

Acmadenia laevigata Bartl. & Wendl. is described afresh as *Euchaetis meridionalis*. *Euchaetis laevigata* Turcz. (= *Acmadenia assimilis* Sond.) is redescribed in order to clarify its difference from *Euchaetis meridionalis*. Two new species of *Euchaetis*, four new species of *Acmadenia* and one new species of *Macrostylis* are described. *Diosma wittebergensis* is transferred to the genus *Acmadenia*.

UITTREKSEL

STUDIES IN THE GENERA VAN DIE DIOSMEAE (RUTACEAE): 7

Acmadenia laevigata Bartl. & Wendl. word as *Euchaetis meridionalis* opnuut beskryf. *Euchaetis laevigata* Turcz. (= *Acmadenia assimilis* Sond.) word weer beskryf om sy verskil van *Euchaetis meridionalis* te beklemtoon. Twee nuwe *Euchaetis* soorte, vier nuwe *Acmadenia* soorte en een nuwe *Macrostylis* soort word beskryf. *Diosma wittebergensis* word by *Acmadenia* ingedeel.

***Euchaetis meridionalis* Williams, sp.nov. affinis *E. scabricosta* Williams sed costis paucioribus glanduloso-punctatis, foliis orbicularibus non lanceolatis, et capitulis ad basim in axilibus resiniferis differt.**

Frutex ad 1,5 m, ad basim monocaulis. *Rami* numerosi, erecti, glabri, brevi. *Ramuli* numerosi, erecti, brevi, sparsim puberuli, dense foliosi. *Folia* ad 6 mm longa, 3,5 mm lata, elliptica vel orbiculares, obtusa, 4-5 faria, sub-complicata, breve petiolata, sub-imbricata, erecta, glabra, sparsim ciliolata, costis marginibusque pauci-glanduloso-punctatis. *Inflorescentia* terminilia, 5-6 nata. *Bractea* 4 mm longa, 2-3 mm lata, elliptica vel orbiculares, obtusa, glabra, sessilia, crassiuscula, intus ad basim resiniferis, marginibus anguste cartilagineis sparsim spinulosus. *Bracteolae* duae, 2,5 mm longae, 1,2 mm latae, sub-ellipticae, glabrae, ciliolatae, ad basim resiniferis. *Sepala* quinque, 2,5 mm longa, 2-2,3 mm lata, sub-elliptica, glabra, sparsim ciliolata. *Petala* quinque, 5,2 mm longa, 3,1 mm lata, sub-rosea vel alba, orbiculata, unguibus transverse barbatis, ciliatis. *Staminodia* quinque, vestigialia. *Fila* quinque, glabra, post anthesin 1,5 mm longa. *Antherae* quinque, 1,2 mm longae, 0,9 mm latae, roseae, apicibus minute glandulosus. *Pollen* 45-50 μ longum, 30-33 μ latum, oblongum. *Discus* ovarium excedens, viridus, nec-tarifer. *Stigma* 0,5 mm diam., capitatum. *Stylus* 1,4 mm longus, glaber, erectus. *Ovarium* 5-carpellatum, 1 mm diam., 0,9 mm longum, apicibus obtusis sparsim

setulosus. *Fructus* 5-carpellatus, 7 mm longus, 4,5 mm diam., glaber, multi-glandulosus, cornibus 2 mm longis, erectis. *Semen* 3,8–4,2 mm longum, 1,5 mm latum, piceum, nitens.

Type: CAPE—3420 (Bredasdorp): De Hoop behind sand dunes on track to Koppie Alleen, Bredasdorp Division (-AD), 14/4/1972, *Williams 1644* (NBG, holotype).

Acmadenia laevigata Bartl. & Wendl. (1824) is the earliest name that was applied to this species but the epithet "laevigata" cannot be transferred to *Euchaetis* due to the prior existence of the name *Euchaetis laevigata* Turcz. (1858). The name *Euchaetis meridionalis* is therefore proposed to embrace this taxon which is here described *de novo*.

Shrubs up to 1,5 m, usually much less, forming a dense rounded bush, single stemmed at base, sometimes in close mats. *Branches* numerous, erect, short, glabrous, di-trichotomous, somewhat rough with leaf scars. *Branchlets* numerous, erect, short, sparsely puberulous, densely foliate. *Leaves* up to 6 mm long, 3,5 mm broad, elliptic or orbicular, obtuse, sub-imbricate, erect, glabrous, 4–5 ranked, somewhat complicate; midrib prominent with 2 or 3 gland dots; margins narrowly cartilaginous, sparsely ciliolate with a few gland dots; petiole short. *Inflorescence* terminal, 4–6 nate, flowers pale pink to white. *Bract* leaf-like, 4 mm long, 2–3 mm broad, elliptic or orbicular, obtuse, glabrous, sessile, somewhat thick, exuding resin from numerous glands situated towards the axil; margins narrowly cartilaginous, sparsely ciliolate. *Bracteoles* two, 2,5 mm long, 1,2 mm broad, asymmetrically elliptic, glabrous, ciliolate, apex thickened and green, resiniferous below. *Calyx lobes* five, 2,5 mm long, 2–2,3 mm broad, sub-elliptic, glabrous, pinkish; apex thickened; margins broadly translucent below, sparsely ciliolate. *Petals* five, 5,2 mm long; *blade* 2,2 mm long, 3,1 mm broad, glabrous, pale pink to white; *claw* 3 mm long, 1,8 mm broad, transversely bearded and sparsely ciliate above. *Staminodes* five, vestigial or a stalked gland 0,2 mm long. *Filaments* five, becoming 1,5 mm long, glabrous, pale pink, acicular. *Anthers* five, 1,2 mm long, 0,9 mm broad, pink, apex with a minute gland. *Pollen* 45–50 μ long, 30–33 μ broad, oblong. *Disc* dark green, exudes nectar, curling inwards over the ovary. *Stigma* 0,5 mm diam., globose, dark green, capitate. *Style* becoming 1,4 mm long, glabrous, erect. *Ovary* 5-carpellate, 1 mm diam., 0,9 mm long; *lobes* obtuse with a few hairs towards the sides above. *Fruit* 5-carpellate, 7 mm long, 4,5 mm diam., surrounded for the most part by the persistent calyx and petals; *carpel* glabrous with many gland dots; *horn* 2 mm long, erect with a few hairs above, apex retuse with a gland. *Seed* 3,8–4,2 mm long including the white aril, 1,5 mm broad, black, shining.

SPECIMENS EXAMINED

CAPE—3420 (Bredasdorp): De Hoop, behind sand dunes on track to Koppie Alleen (-AD), 200 ft., 14/4/1972, *Williams 1644* (NBG); De Hoop, flats, lime-

stone hills and along pass to Wydgelegen, 8/4/1957, *Lewis 5130* (BOL, NBG), 9/6/1970, *Esterhuysen 32461* (BOL), 10/3/1957, *Barker 8735* (NBG), -/7/1962, *Macpherson s.n.* (NBG), 5/2/1963, *Jordaan M227* (STE), c 100 ft., 28/7/1970, *v.d. Merwe 137* (STE); De Hoop, N. side of pass, 415 ft., 9/4/1974, *Williams 1888* (NBG); De Hoop, S. side of pass, 200 ft., 9/4/1974, *Williams 1890* (NBG), 175 ft., 27/11/1974, *Williams 1940* (NBG); Potberg, Elands Pad, near the coast (-BC), 100 ft., 12/4/1972, *Williams 1638* (NBG); Cape Infanta, Sebastian Bay (-BD), 28/9/1959, *Esterhuysen 28314* (BOL), 23/9/1947, *Walgate 874* (NBG), *Kunth s.n.* (MEL 52824); Arniston, Wagenhuiskraal, Kliprug (-CA), 15/9/1944, *Henrici 3716* (BOL, NBG), 5/6/1900, *Fry s.n.* (GRA, PRE), 0-150 ft., 24/8/1962, *Taylor 3807* (PRE, STE), 90 ft., 20/9/1968, *Marsh 919* (PRE, STE), -/7/1933, *Jordaan s.n.* (STE 18672); Dronkvlei, 100 ft., 26/8/1963 *van Breda 1636* (K, PRE); 3,4 miles N.W. of Skipskop (-CB), 100 ft., 22/6/1962, *Acocoks 22268* (K, PRE); Skipskop behind the dunes, 50 ft., 9/4/1974, *Williams 1891* (NBG); Struis Bay near sea (-CC), 1/12/1933, *Salter 4104* (BM, BOL, K), 50 ft., 21/6/1972, *Williams 1661* (NBG); Cape Agulhas 2 miles east and rocks along coast, 16/9/1934, *Salter 4836* (BM, BOL, K), 5/8/1940, *Esterhuysen 2975* (BOL, GRA, K, NBG, SAM), 4/8/1940, *Compton 9081* (NBG); prope Zoutendals valley, -/10/-, *Ecklon & Zeyher 824* (S).

Without locality: *Scholl s.n.* (B-W 4784 as to r.-hand specimen), *Mundt s.n.* (SAM 30579 as to r.-hand specimen), *Guenzius s.n.* (W), *Sieber s.n.* (W). (*Ecklon & Zeyher 826* (S, SAM) from between Pampoenkraal and Paarl is an extremely doubtful locality).

DISTRIBUTION AND BIOLOGY

Euchaetis meridionalis occurs in a fairly narrow coastal area lying between Cape Agulhas and Cape Infanta usually close to the coast but, at only one point near Wydgelegen, reaching as far as thirteen kilometres from the sea. It is by no means rare and can form dense mats in exposed areas near to the sea (*Esterhuysen 2975*). It is usually found at altitudes of from 15 to 60 m (50-200 ft.) above sea level, growing on limestone associated with the Bredasdorp geological series. It has been observed in bloom from April to December and ripe fruits have been collected from August to November. The small but conspicuous flowers, the sticky pollen and the presence of nectar indicate that this plant is most probably pollinated by insects. An assumption confirmed by the observation of honey bees visiting the flowers (*Williams 1638*). Regeneration takes place, probably only after fires, from seed which has been ejected when ripe from the capsule by the usual catapult mechanism. The leaves, when crushed, have an odour reminiscent of cedar and may exhibit a whitish waxy exudate originating as a sticky resin near the axils of the young leaves. On farm lands the plants have been observed to have been grazed by stock (*Williams 1644*, *Henrici 3716*).

VARIATION

It is quite noticeable that the leaves of plants from near the sea at Struisbaai are shorter and broader than those of the plants from further inland and that those from the farthest inland, near to Wydgelegen, are beginning to look very much like those of *Euchaetis scabricosta* indicating a very close relationship between these two species.

DISCUSSION

Because of the transversely bearded petals this plant may be regarded as a typical *Euchaetis*. It may be distinguished from *Euchaetis scabricosta*, as previously mentioned (Williams, 1974), having a midrib with fewer gland dots, leaves that are more obtuse, more crowded, shorter and broader, with a resinous exudate towards the leaf axils. Furthermore a recent gathering of *Euchaetis scabricosta* (Williams 2181) from near Bredasdorp has shown that, whereas *E. scabricosta* may regenerate after fires by sprouting from the rootstock just below ground level, *E. meridionalis*, being single stemmed at base, has never been observed to do this. A most notable difference between these two species is that *E. meridionalis* is only found on limestone whereas *E. scabricosta* is found in sandy soil.

REFERENCE

WILLIAMS, ION, 1974. *Jl S. Afr. Bot.* **40** (4): 286-289.

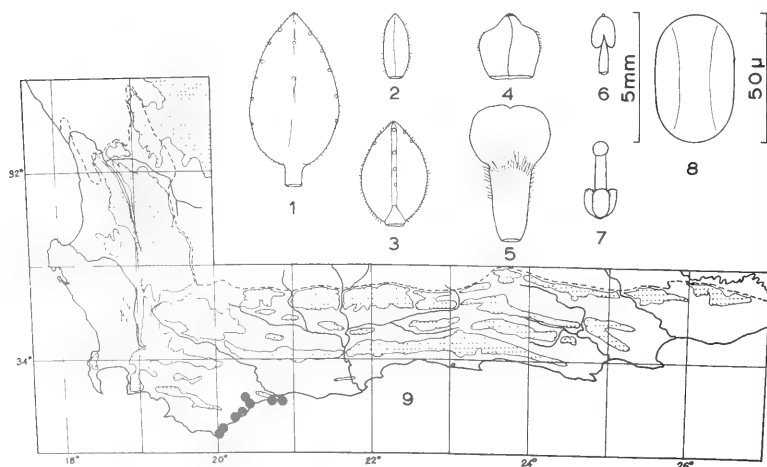


FIG. 1.

Euchaetis meridionalis: 1, leaf. 2, bracteole. 3, bract. 4, calyx lobe. 5, petal. 6, anther. 7, gynoecium. 8, pollen. 9, distribution.

Euchaetis laevigata Turcz. in *Bull. Soc. Imp. Nat. Mosc.* **31**. 1:438 (1858). Type: between Cape Agulhas and Potberg, on limestone hills, under 500 ft., 3/8/1831, Drège IV, C, a, 2 (BM, E, K, MEL, P, S, isotypes).

Acmadenia laevigata E. Mey in Drège Zwei pflanzen. Doc.: 122, 161 (1844). nom. nud.

Acmadenia assimilis Sonder in Flor. Cap. **1**: 383 (1860). Type: as above.

It is most extraordinary to think that this plant collected by Drège in 1831 on limestone hills between Cape Agulhas and Potberg should have passed unnoticed until comparatively recently when Acocks gathered specimens on the north side of the limestone hills between Bredasdorp and Wydgelegen. Following Acocks' lead, further material was collected from quite near Bredasdorp, just beyond the lime quarry on the Swellendam road. It was found to be a perfect match with the specimens collected by Drège and named *Acmadenia laevigata* by E. Meyer. Sonder, unaware of Turcszaninov's paper, named Drège's plant *Acmadenia assimilis*, the name *Acmadenia laevigata* having been previously used by Bartling and Wendland for another taxon in this genus. Although Sonder's action was correct, local botanists were confused and for many years assigned plants found between Cape Agulhas and Potberg to *Acmadenia assimilis* in error. Because of this misidentification it has been deemed advisable to redescribe *Euchaetis laevigata* at the same time as publishing the description of *Euchaetis meridionalis* which now replaces *Acmadenia laevigata* B. & W. At the same time attention is drawn to the fact that the three species mentioned by Sonder: (11) *A. laevigata* B. & W., (12) *A. pungens* B. & W. and (13) *A. assimilis* Sond., considered by Sonder to belong in *Acmadenia*, all possess transversely bearded petals and rudimentary staminodes and have therefore been placed in *Euchaetis* under the names *E. meridionalis* Williams, *E. pungens* (B. & W.) Williams and *E. laevigata* Turcz. in that order.

DESCRIPTION

Shrubs up to 0,8 m tall, erect, forming a dense bush single stemmed at base. *Branches* erect, often dichotomous, slender, with a greyish bark becoming fairly smooth and leafless after about three seasons. *Branchlets* numerous, erect, slender, somewhat reddened, glabrous, except for some minute puberulence, often in opposite pairs. *Leaves* 2,8–3,6 mm diam., orbicular, sessile, 4-ranked, opposite, recurved-erect, glabrous, very sparsely and minutely ciliolate; apex with a blunt point; margins narrowly translucent and somewhat denticulate, subcomplicate with a distinct midrib and scattered oil glands; adaxial surface somewhat concave. *Inflorescence* terminal, with the white flowers in opposite pairs or fours below which the next years shoots emerge. *Bract* one to each flower, 2,5 mm long 1,6–2,4 mm broad, ciliolate, leaf-like. *Bracteoles* two 2,5 mm long, 1,3–1,6 mm broad, elliptic, obtuse, glabrous, keeled, apex thickened; margins minutely ciliolate and translucent below. *Calyx lobes* five, about 2,5 mm diam., asymmetrically

orbicular, glabrous, minutely ciliolate, thickened and spreading at the apex; the margins broadly translucent below. *Petals* five, 4,5 mm long; *limb* 1,6–1,8 mm long, 2,2–2,5 mm broad, sub-orbicular, glabrous, pinkish-white; *claw* 2,5 mm long, 1,5 mm broad narrowing to 0,8 mm below, more or less translucent, transversely bearded above, ciliate, a few hairs down the prominent midrib. *Staminodes* five, vestigial, a minute gland about 0,1 mm long at most, situated low down on the outside of the disc. *Filaments* five, at first 0,5 mm long becoming 1,8 mm long after anthesis and placing the discharged anther outside the perimeter of the claws. *Anthers* five, 1 mm long before anthesis, reddish-orange, with a minute apical gland. *Pollen* 50–55 μ long, 28–30 μ broad, oblong. *Disc* minutely punctate, dark green, closes somewhat over the ovary, exudes nectar. *Stigma* 0,6 mm diam., globose, capitate. *Style* becoming 1,2 mm long, glabrous, erect, persisting. *Ovary* 5-carpellate, each carpel with a gland clasped at the apex and minute spiky lumps along adjacent edges. *Fruit* 5-carpellate, 5,5 mm long, about 3,8 mm diam., glabrous, smooth; *carpels* with about 6 gland dots along the margins and a few very short hairs above; *horns* 1 mm long or less, erect, clasping a small gland at the apex, equalling the persistent stigma. *Seed* (from *Williams* 2025) 2,7–3 mm long with the white aril produced a further 0,6 mm, 1,5 mm broad, black, shining.

SPECIMENS EXAMINED

CAPE—3420 (Bredasdorp): van der Stelskraal (-AC), 400 ft., 1/8/1968, *Acocks* 24042 (PRE), 300 ft., 2/7/1972, *Williams* 1662 (NBG); Soutpansvlakte, 8 miles E. of Bredasdorp, 340 ft., 4/6/1974, *Williams* 1904 (NBG); 3 km N.E. of Bredasdorp on road to Swellendam (-CA), 300 ft., 21/11/1973, *Williams* 1874 (NBG), 3/8/1975, *Williams* 2025 (NBG); between Cape Agulhas and Potberg, on limestone hills, under 500 ft., 3/8/1831, *Drège* IV, C, a, 2 (BM, E, K, MEL, P, S, isotypes).

DISTRIBUTION AND BIOLOGY

Euchaetis laevigata occurs quite frequently over a rather small area about 23 km long on the N side of the limestone ridge running NE from Bredasdorp at an altitude of 90–120 m (300–400 ft.) above sea level. It was found in full bloom in the middle of October but at other times only a few plants with flowers were seen and only one plant with fruits was found in August. It is possible that the extremely dry winters experienced at that time may have been the reason. The plant is single stemmed at base and apparently will not regenerate after fires from the stump so that one presumes that it can only regenerate from seed.

VARIATION

No variation or hybridisation had been observed but the plants at van der Stelskraal were the tallest and most healthy.

DISCUSSION

The transversely bearded petals and the vestigial staminodes indicate that this plant is a typical *Euchaetis*.

It differs from both *Euchaetis scabricosta* and *Euchaetis meridionalis* in having leaves that are always opposite with the midrib recurved, somewhat smaller, orbicular in outline with gland dots scattered and not just on midrib and margins. The shoots are dry without any trace of resin or wax.

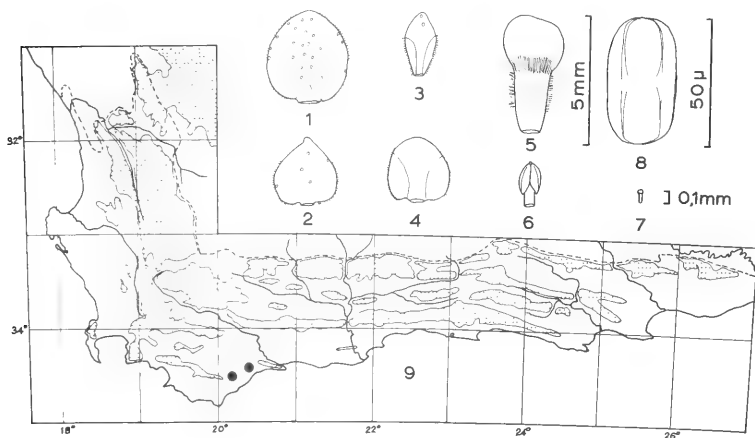


FIG. 2.

Euchaetis laevigata: 1, leaf. 2, bract. 3, bracteole. 4, calyx lobe. 5, petal. 6, anther. 7, staminode. 8, pollen. 9, distribution.

***Euchaetis intonsa* Williams, sp. nov.**, propria propter folia alterna elliptica sparsim pubescentia ciliata, bracteae bracteolae et sepala pubescentes, petala parva costis intus glabris.

Frutex 400 mm, ad basim monocaulis. *Rami* numerosi, erecti, glabrescenti, cinerei. *Ramuli* numerosi, erecti, puberuli, graciles, ex parte rubelli, foliosi, irregulariter alterni. *Folia* 4 mm longa, 2.2–2.4 mm lata, elliptica, sub-acuta, sub-erecta, pleurumque alterna; costis prominentibus, glanduloso-punctatis, sparsim pubescentibus, ad apex callosis; marginibus sparsim ciliatis, minute glanduloso-punctatis. *Inflorescentia* terminalis, sessilis, 3–4 nata. *Bractea* una, 2.7 mm longa, 1.1–1.7 mm lata, oblanceolata, obtusa, ciliata, sparsim pubescens. *Bracteolae* duae, 2.5 mm longae, 1 mm latae, oblongae, obtusae, ciliatae, pubescentes. *Sepala* quinque, 2.6 mm longa, 2 mm lata, asymmetricce oblonga, conspicua, purpurata, ciliata, sparsim pubescentia. *Petala* quinque, 3.8–4.2 mm longa; *limbus* 1.3–1.8 mm latus, sub-orbicularis, subroseus; *unguis* (♂) 1 mm

latus, forte transverse barbata, ciliata. *Staminodia* quinque, 0,1 mm longa, vestigiala. *Filamenta* quinque, glabra, post anthesin 1,5 mm longa. *Anthera* quinque, 1 mm longa, 0,7 mm lata, aurantia. *Pollen* 52 μ longum, 30 μ latum, oblongum. *Discus* ovarium excedens, viridus, nectarifer. *Stigma* 0,6 mm diam., globosum, capitatum. *Stylus* 1,3 mm longus, glaber, erectus. *Ovarium* 5-carpellatum, 0,7 mm longum, 0,6 mm diam., apicibus obtusis, lateribus sparsim setulosus. *Fructus* 5-carpellatus, 6,5 mm longus, 4 mm diam., viridus; *cornibus* 1 mm longis, erectis, echinulatis. *Semen* 3,7 mm longum, arillatum, 1,6 mm latum, piceum, nitens.

Type: CAPE—3420 (Bredasdorp): north side of pass from Wydgelegen to De Hoop, at base of limestone hills, on gently sloping ground in crevices and in shallow soil on limestone bedrock (-AD), 100 m (350 ft.), 3/8/1975, *Williams* 2028 (NMG, holotype; K, MO, NSW, PERTH, PRE, S, STE, isotypes).

Euchaetis intonsa was apparently first collected by J. P. H. Acocks in December 1962.

Shrubs up to 400 mm tall forming a dense rounded bush if undisturbed, single stemmed at base. *Branches* fairly numerous, somewhat erect, smooth, glabrescent as the outer skin splits off, ashy grey. *Branchlets* numerous, erect, puberulous, reddened where exposed, fairly slender, well clothed with leaves, irregularly alternate. *Leaves* 4 mm long, 2,2–2,4 mm broad, smaller on branchlets, elliptic, sub-acute, sub-erect, alternate, sometimes 4-ranked on small shoots near the base of the plant; midrib prominent, gland-dotted, apex callused; abaxial surface sparsely pubescent mainly on the midrib; margins thick, sparsely ciliate, minutely gland-dotted; adaxial surface glabrous; petiole 0,5 mm long, adpressed, glabrous, pale. *Inflorescence* terminal, 3–4 nate, sessile; florets crowded, flowering simultaneously. *Bract* one to each flower, 2,7 mm long, 1,1–1,7 mm broad, oblanceolate, obtuse; apex thick, green, somewhat elevated; margins ciliate, translucent below; midrib prominent; abaxial surface sparsely pubescent, without gland dots. *Bracteoles* two, 2,5 mm long, 1 mm broad, oblong, obtuse; apex thick, green; margins ciliate; abaxial surface pubescent. *Calyx lobes* five, 2,6 mm long, 2 mm broad, oblong, asymmetrical in outline, conspicuous, purplish; apex elevated, obtuse; margins ciliate, broadly translucent, pinkish; abaxial surface thinly pubescent. *Petals* five, 3,8–4,2 mm long; *limb* 1,3–1,8 mm broad irregularly orbicular, pinkish, becoming recurved; *claw* 0,8–1 mm broad, strongly transversely bearded, ciliate above. *Staminodes* five, 0,1 mm long, vestigial, pale, minutely stalked, arising on the outside base of the disc. *Filaments* five, becoming 1,5 mm long, acicular, glabrous. *Anthers* five, 1 mm long, 0,7 mm broad, reddish-orange in colour with a minute spherical apical gland pointed inwards; thecae pointed at apex and base. *Pollen* 52 μ long, 30 μ broad, oblong. *Disc* exceeds the ovary by a long way, level on top, bright green, exudes nectar. *Stigma* 0,6 mm diam., globose, capitate. *Style* becoming 1,3 mm long, glabrous, erect. *Ovary* 5-carpellate, 0,7 mm long, 0,6 mm diam., apices hemispherically obtuse with a

few hairs at the sides. *Fruit* (from *Williams 2238*) 5-carpellate, 6,5 mm long, 4 mm diam., green, glabrous except for a few hairs on the margins and upper adaxial surfaces; *horns* \pm 1 mm long, erect, emarginate; apex bristly with very short hairs; style persisting. *Seed* 3,7 mm long including the white aril (0,7 mm long), 1,6 mm broad, black, shining.

SPECIMENS EXAMINED

CAPE—3420 (Bredasdorp): north side of pass from Wydgelegen to De Hoop, at base of limestone hills (-AD), 100 m, 3/8/1975, *Williams 2028* (NBG, K, MO, NSW, PERTH, PRE, S, STE). 9/4/1974, *Williams 1887* (NBG), 9/11/1976, *Williams 2338* (NBG); 2 miles south of Wydgelegen PO, Kalk Coastal Fynbos, occasional in valley, 400 ft, 17/12/1962, *Acocks 23169* (PRE).

DISTRIBUTION AND BIOLOGY

Up to now *Euchaetis intonsa* has only been found in one locality on the north slopes of the limestone hills running from Bredasdorp to Potberg in the vicinity of Wydgelegen. It would therefore certainly appear to be very rare. Collections of flowering material made in March, when few flowers were found, and in August when many buds were found, indicate a rather prolonged flowering period. Ripe fruits were collected in November. The presence of nectar is one indication that this plant is insect pollinated. Regeneration after fires would appear to be only from seed as the plant is single stemmed at base and the root shows no sign of previous burning off.

VARIATION

Upon encountering a species with such a limited distribution one might expect it to be a hybrid or variant. However in this case, as no probable parent plants have been found, hybridisation or variation would appear to be ruled out.

DISCUSSION

The strongly bearded petals most decidedly place this plant in the genus *Euchaetis*.

E. intonsa is a distinct species having leaves alternate, elliptic, sparsely pubescent and ciliate, with bracts, bracteoles and calyx lobes pubescent and with petals small with the midrib glabrous on the inside. It differs from *E. burchellii*, *E. laevigata* and *E. scabricosta* which have opposite leaves, glabrous bracts and glabrous calyx lobes. Although *E. meridionalis*, a more glabrous plant, is found nearby and may also have 4 or 5-ranked leaves, it differs from *E. intonsa* which has smaller, sparsely pubescent, leaves and pubescent bracts, bracteoles and calyx lobes. The epithet "*intonsa*" refers to this hairiness.

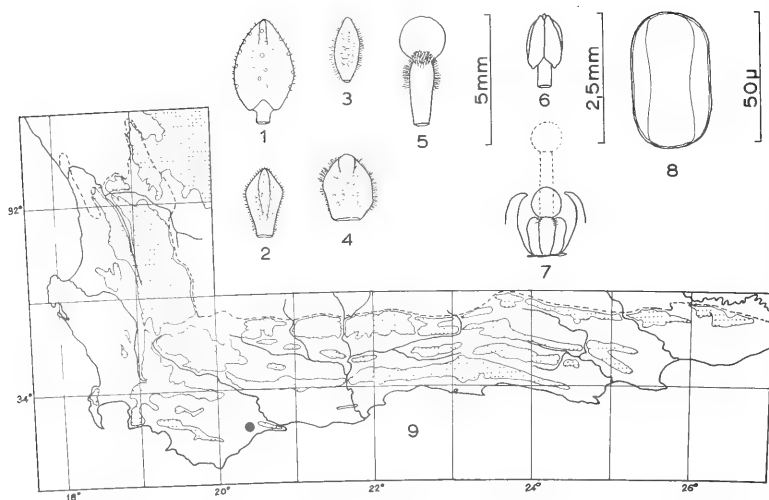


FIG. 3.

Euchaetis intonsa: 1, leaf. 2, bract. 3, bracteole. 4, calyx lobe. 5, petal. 6, anther. 7, gynoecium with section of disc. 8, pollen. 9, distribution.



FIG. 4.

Euchaetis intonsa showing the transversely bearded petals.

Euchaetis avisylvana Williams, sp. nov. propria propter folia glabra longi-ciliata, sepalal lanceolata acuta alba petaloidea, petala acutissima.

Frutex 1 m, ad basim monocaulis. *Rami* numerosi, recti, graciles, 2–3-chotomi, glabri. *Ramuli* erecti, graciles, recti, glabri, foliosi. *Folia* 11–14 mm longa, 1,2–1,4 mm lata, lineari-lanceolata, glabra, acuta, mucronata, longi-ciliata, erecta, sub-imbricata, alterna, glanduloso-punctata breve petiolata. *Inflorescentia* terminalis, ad 19 aggregata, alba. *Bractea* 7 mm longa, 1–2 mm lata, lineari-lanceolata, acuta, glabra, glanduloso-punctata, ad apice ciliata. *Bracteolae* duae, 4,2–4,5 mm longae, 1 mm latae, lanceolatae, acutae, glabrae, sparsim glanduloso-punctatae. *Sepala* quinque, 5 mm longa, 1,5–1,8 mm lata, lanceolata, acuta, glabra, eciliata, alba, petaloidea, persistentes. *Petala* quinque, 5 mm longa; *limbus* 2,5 mm longus, 1,1 mm latus, lanceolatus, acutissimus, glaber; *unguis* 2,5 mm longus, 1,5 mm latus, ovatus, forte transverse-barbatus, ciliatus. *Staminodia* quinque, 0,1 mm diam., vestigialia. *Fila* quinque, post anthesin 1,3 mm longa, glabra, acicularis. *Antherae* quinque, 1 mm longae, 0,7 mm latae, vinosae, apicibus minute glandulosis. *Pollen* $\pm 43 \mu$ longum, $\pm 21 \mu$ latum, oblongum. *Discus* 5-sinuato-crenulatus, apertus, pallido-viridus, nectarifer, ovarium excendens. *Stigma* 0,25 mm diam., pallido-viridum, capitellatum. *Sylus* initio deflexus, deinde erectus, 1 mm longus, glaber. *Ovarium* 5-carpellatum, 0,7 mm longum, 0,8 mm diam., glabrum. *Fructus* 5-carpellatus, 7 mm longus, 6 mm diam., glaber, laevis, sparsim glanduloso-punctatus, breve pedicellatus; *cornibus* 1–1,5 mm longis, erectiusculis. *Semen* 4,6 mm longum, 2,4 mm latum, piceum, nitens.

Type: CAPE—3320 (Montagu): Grootvadersbos, on a stony south facing shoulder, Heidelberg Division (-DD), 425 m (1 400 ft.) alt., 29/4/1975, Williams 1997 (NBG, holotype; BOL, C, GRA, K, M, MO, NSW, PERTH, PRE, S, STE, isotypes).

This comparatively rare plant was first discovered by Miss Elsie Esterhuysen in September 1944 on the south slopes of the Langebergen near Strawberry Hill. This is the name of a farm adjacent to the Grootvadersbos Forest Reserve.

Shrubs 1 m tall, branching from near the base into a diffuse bush spreading about 1 m diam. *Branches* numerous, slender, fairly straight, di-trichotomous, glabrous, brown with the pale outer skin splitting off, smooth but for the small leaf scars. *Branchlets* erect, slender, straight, glabrous, pale green, well clothed with leaves. *Leaves* 11–14 mm long, 1,2–1,4 mm broad, linear-lanceolate, glabrous, erect, sub-imbricate alternate; apex acute, incurved, mucronate with a few minute hairs; margins villous-ciliate and narrowly cartilaginous; adaxial surface somewhat concave; abaxial surface with a row of gland dots on either side of the midrib; narrowed at the base to a short yellowish petiole. *Inflorescence* terminal, up to 9 florets crowded together on short branchlets or pedicels, the most advanced being nearest to the apex of the main axis. *Bract* one to each flower, 7 mm long, 1,2 mm broad, linear-lanceolate, acute, glabrous, incurved, tipped with three minute hairs, margins ciliate above, narrowly translucent below, gland dotted to

either side of the midrib, sub-sessile. *Bracteoles* two, 4.2–4.5 mm long, 1 mm broad, narrowing evenly to the apex, lanceolate, acute, glabrous, tipped with one or two minute hairs, margins eciliate and narrowly translucent, sparsely gland-dotted, sessile. *Calyx lobes* five, 5 mm long, 1.5–1.8 mm broad, lanceolate, acute, glabrous, eciliate, white, erect, petaloid, persisting, with about 5 indistinct gland dots. *Petals* five, 5 mm long; *limb* about 2.5 mm long, 1.1 mm broad, glabrous, lanceolate-acute, recurved, sub-apiculate; *claw* about 2.5 mm long, 1.4 mm broad, ovate, strongly transversely bearded across the top, margins crisped ciliate, delapsing soon after anthesis. *Staminodes* five, 0.1 mm diam., a vestigial hemispherical lump on the perimeter of the disc. *Filaments* five, becoming 1.3 mm long, glabrous, acicular. *Anthers* five, 1 mm long, 0.7 mm broad, wine coloured with a small globose apical gland. *Pollen* $\pm 43 \mu$, $\pm 21 \mu$ broad, oblong. *Disc* 5-sinuo-crenulate, more or less erect around the ovary exceeding it somewhat, pale green, exudes nectar. *Stigma* 0.25 mm diam., capitellate, pale green. *Style* deflexed at first, becoming 1 mm long, erect, glabrous. *Ovary* 5-carpellate, 0.7 mm long, 0.8 mm diam., glabrous with the carpels leaning inward towards the apex. *Fruit* (from *Williams 2071*) 5-carpellate, 7 mm long, 6 mm diam., glabrous, smooth, indistinctly gland-dotted, pink tinged below; *horns* very short, 1–1.5 mm long, fairly erect, purple tipped. *Seed* 4.6 mm long, 2.4 mm broad, black, shining; *aril* much reduced, black.

SPECIMENS EXAMINED

CAPE—3320 (Montagu): Strawberry Hill, lower south slopes of Langebergen on the steep slope above kloof (-DD), 2 000 ft., 10/9/1944, *Esterhuysen 10406* (BOL, K, NBG); Rocky slopes above stream at Naauwkrans on lower slopes of Langebergen near Heidelberg, 28/3/1948, *Esterhuysen 14444* (BOL, K, NBG); Strawberry Hill vicinity near Heidelberg, 1 800 ft., 21/7/1952, *Wurts 245* (NBG); Grootvadersbos, 6/4/1959, *Barker 8954* (NBG); Langeberg, between Lemoenshoek and Naauwkrantz, farm Strawberry Hill, 11/1/1957, *Stokoe s.n.* (NBG); Grootvadersbos, stony south facing shoulder, Heidelberg Div., 425 m (1 400 ft.), 29/4/1975, *Williams 1997* (NBG, BOL, C, GRA, K, M, MO, NSW, PERTH, PRE, S, STE); Tradouw Pass, south side near the cave, Heidelberg Div. (-DC), 1 000 ft., 10/9/1975, *Williams 2068* (NBG); Tradouw Pass, rocky shoulder about one third of way up, 1 100 ft., 10/9/1975, *Williams 2071* (NBG).

DISTRIBUTION AND BIOLOGY

Euchaetis avisylvana has been found only in a few places on the south slopes of the Langeberg range from Tradouw Pass eastwards for about 17 kilometres at altitudes of from 300–600 m (1 000–2 000 ft.). It grows on rocky or stony places in well drained acid soil derived from the Table Mountain Sandstone. It flowers from March until about September when ripe fruits may be collected. The reproductive parts of the flower are well protected by the bearded ciliate petals

which however delapse long before the fruit has ripened leaving the pale persistent calyx lobes which look rather like petals. The flowers have a pungent smell rather like the excreta of otters, exactly similar to that of *E. longicornis*, but differing from that of *E. elata* which smells of cats' urine. These facts and the presence of nectar would indicate that the flowers are most probably pollinated by insects. Being single stemmed at base, without any stout persistent root, regeneration after fires can only take place from the seed which is ejected by the usual catapult mechanism when ripe. This is a factor which could make this plant susceptible to elimination by too frequent burning of the habitat. As it is, it appears to be in a precarious position as relic populations in the Tradouw Pass are at present being eliminated by road building and the population at Grootvadersbos is standing beneath the trees in a pine plantation belonging to the Department of Forestry.

DISCUSSION

The strongly bearded petals and the vestigial staminodes are the main characters which place this plant in the genus *Euchaetis*.

Euchaetis avisylvana is distinct on account of having villous-ciliate leaves tipped with a few hairs at the apex; lanceolate-acute, white, somewhat petal-like tipped with a few hairs at the apex; lanceolate-acute, white, somewhat petal-like

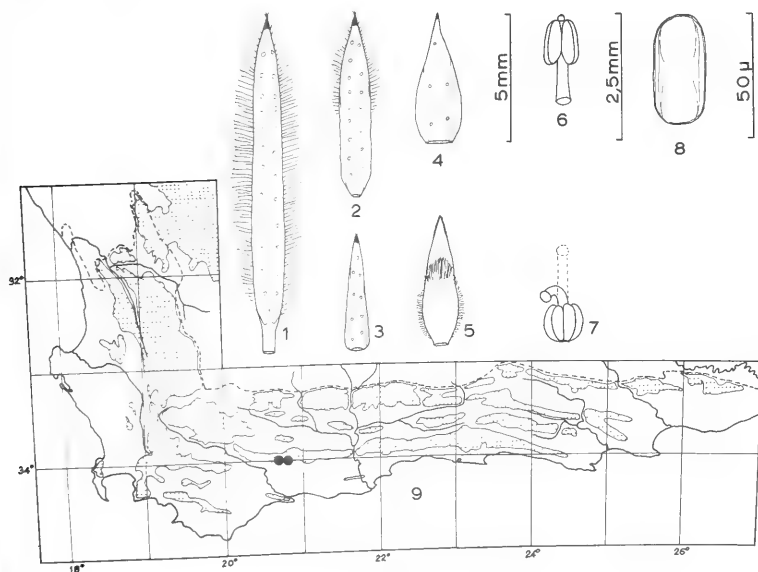


FIG. 5.

Euchaetis avisylvana: 1, leaf. 2, bract. 3, bracteole. 4, calyx lobe. 5, petal. 6, anther. 7, gynoeceum. 8, pollen. 9, distribution.

calyx lobes and acute petals. It differs from *E. elata* E. & Z. which has leaves, bracts, bracteoles and calyx lobes much shorter and ciliolate not villous-ciliate, and also the blade of the petal elliptic-apiculate not lanceolate-acute. The very short horns of *E. avisylvana* at once distinguish it from *E. longicornis* Williams which has very sharp pointed leaves; bracts, bracteoles and calyx lobes with scattered gland dots. The name is a latinisation of *grootvadersbos*, the locality where the type material was gathered.



FIG. 6.

Euchaetis avisylvana showing the transversely bearded petals and, with petals removed, the disc with vestigial staminodes.



FIG. 7.
Euchaetis avisylvana habit.

Acmadenia patentifolia Williams, sp. nov. propria propter folia parva crassa patentia alterna, flores parvos petalis patentibus, fructum magnum cornibus longis.

Frutex 1 m, 2 m diam., densus, ad basim monocaulis. *Rami* numerosi, erecti, breves, glabri, dichotomi. *Ramuli* numerosi, erecti, brevissimi, sub-flexuosi, glanduloso-punctati. *Folia* 1,8–2,7 mm longa, 1,3–1,6 mm lata, oblongo-lanceolata, obtusa, sessilia, crassa, patentia, alterna, prope basin sparsim puberulis, 2–3 glanduloso-punctata. *Inflorescentia* terminalis, sessilis, 1–2 nata. *Bractea* 1,5 mm longa, 1–1,2 mm lata, foliis similis. *Bracteolae* duae, 1,4 mm longae, 1 mm latae, late-lanceolatae, obtusae, marginibus ad basin translucenibus sparsim ciliolatis puberulisque, intus minute puberulae. *Sepala* quinque, 1,5 mm longa, 1–1,2 mm lata, oblonga, obtusa, ad apicem crassa, marginibus ad basin anguste hyalinis sparsim ciliolatis puberulisque, intus minute puberula. *Petala* quinque, 2,6–2,8 mm longa; *limbus* 2 mm longus, 1,3 mm latus, lanceolatus, obtusiusculus, glaber, 1–3 glanduloso-punctatus. *Staminodia* quinque, 0,8 mm longa, ad apices glandulosa. *Filamenta* quinque, ante anthesin 1,5 mm longa, acicularia, glabra, erecta. *Antherae* quinque, ante anthesin 1 mm longae, 0,6 mm latae, apicibus sessili-glandulosis. *Pollen* 43 μ longum, 23 μ latum, ellipticum. *Discus* viridus, crassus, nectarifer, obvallatus. *Stigma* 0,3 mm diam., capitellatum. *Stylus* 1 mm longus, erectus, glaber, persistens. *Ovarium* 5-carpellatum, 0,8 mm longum, 0,8

mm diam., glabrum, apicibus globosis. *Fructus* 5-carpellatus, 16 mm longus, 7 mm diam., glaber, viridus, multi-glanduloso-punctatus, cornibus 4 mm longis. *Semen* 5–5,6 mm longum arilo exclusa, 2–2,3 mm latum, piceum, nitens; *arillus* 1–1,5 mm longus, albus.

Type: CAPE—3219 (Wuppertal): on track from Krom River to Breckkrantz, South Cedarberg, Clanwilliam Division (-CB), 914 m (3 000 ft.), 18/9/1975, *Williams* 2087 (NBG, holotype; K, MO, M, PRE, S, STE, isotypes).

Acmadenia patentifolia was discovered by Miss Elsie Esterhuysen of the Bolus Herbarium in 1952 at Krom River in the South Cedarberg. She encountered this plant again in 1961 on the Swart Ruggens in the Ceres Division. No further collections were made until 1975 when the material upon which this description was based was gathered near Krom River in the Clanwilliam Division.

Shrubs 1 m tall, spreading to 2 m diam., forming a dense rounded bush with many branches arising from a single stem at base. *Branches* numerous, erect, short, glabrous, irregularly bent, dichotomous; *bark* rough, ashy brown. *Branchlets* numerous, erect, very short, sub-sinuous, sparsely and minutely puberulous, reddish, lumpy with oil glands at open spaces, often encrusted with small pieces of a red resinous exudate at the base of the leaves. *Leaves* 1,8–2,7 mm long, 1,3–1,6 mm broad, oblong-lanceolate, obtuse, thick, sessile, spreading, alternate; apex with an immersed callus; margins rounded with the cartilage immersed; midrib rounded with 1–3 gland dots; the base thinly puberulous clasping the stem. *Inflorescence* terminal, sessile, solitary or paired; *flower* 6 mm diam., with the white petals spreading to reveal the green calyx lobes and the green disc; *calyx* minutely puberulous. *Bract* 1,5 mm long, 1–1,2 mm broad, leaf-like, somewhat ciliolate at base. *Bracteoles* two, 1,4 mm long, 1 mm broad, broadly lanceolate, obtuse, 1–3 gland-dotted; margins below broadly translucent, minutely and sparsely ciliolate, thinly puberulous; adaxial surface minutely puberulous. *Calyx lobes* five, 1,5 mm long, 1–1,2 mm broad, oblong, obtuse, thick at the apex, sparsely gland-dotted, sparsely and minutely puberulous inside and at the sides below. *Petals* five, 2,6–2,8 mm long; *limb* 2 mm long, 1,3 mm broad, lanceolate, sub-obtuse, glabrous, 1–3 gland-dotted, white, spreading-recurved, margins minutely denticulate; *claw* 0,8 mm long, smooth. *Staminodes* five, 0,8 mm long, 0,25 mm broad at base, transversely flattened below, arising near the base of the petal, apical gland 0,15 mm diam., globose, pale yellow. *Filaments* five, becoming 1,5 mm long, acicular, glabrous, erect. *Anthers* five, before anthesis 1 mm long, 0,6 mm broad, apical gland small semi-immersed. *Pollen* 43 μ long, 23 μ broad, elliptic. *Disc* erect, green, thick, exudes nectar, slightly exceeds the ovary. *Stigma* almost 0,3 mm diam., capitate. *Style* becoming 1 mm long, erect, glabrous, persisting. *Ovary* 5-carpellate, 0,8 mm long, 0,8 mm diam., glabrous, apices globose. *Fruit* 5-carpellate, 16 mm long, 7 mm diam., glabrous, green, multi-gland-dotted; *horns* 4 mm long, spreading at $\pm 45^\circ$, tinged with purple,

apex with a small immersed gland. Seed 5–5.6 mm long excluding the aril, 2–2.3 mm broad, black, shining; aril 1–1.5 mm long, white.

SPECIMENS EXAMINED

CAPE—3219 (Wuppertal): rocky ridge, Krom River, South Cedarberg, Clanwilliam Division (-CB), 3 000–4 000 ft., 4/10/1952, *Esterhuysen 20542* (BOL); on track from Krom River to Breekrantz, South Cedarberg, Clanwilliam Division, 914 m (3 000 ft.), 18/9/1975, *Williams 2087* (NBG, K, MO, M, PRE, S, STE); on rocky plateau, Stompiesfontein, Swaruggens, Ceres Division (-DC), 4 000 ft., 19/11/1961, *Esterhuysen 29351* (BOL).

DISTRIBUTION, BIOLOGY AND VARIATION

Acmadenia patentifolia, with its insignificant flowers, has very seldom been gathered. Although dominant in the small areas where it has been found it appears to be a very rare plant. Being in some respects (i.e. the fruit), remarkably like a *Diosma* it would be a pity if this possible link with the *Acmadenia* were to be lost. It has been found growing on a stony quartzitic ground derived from Cape Geological System in, as far as is known, only two localities, about 40 km apart, both falling within the winter rainfall area of the South Western Cape. No variation has been noted.

The little white flowers, with spreading petals exposing the nectariferous disc, are most probably pollinated by insects. The seeds when ripe are ejected by the usual catapult mechanism and regeneration appears to be only from seed. A section, 13 mm diam., from the stem near the base of one rather small plant showed 28 annual rings indicating that fires seldom occur. The leaves have a faint smell of eucalyptus (blue gum) when crushed.

DISCUSSION

Although the wide open flower and the large fruit with long horns give *A. patentifolia* the appearance of a *Diosma*, the presence of staminodes attached at the outer base of the disc adjacent to the petals, the shape of the disc itself, closely surrounding the ovary not open and crenulate, and the rather close resemblance of the whole plant to *Acmadenia tetracarpellata* lead one to place it in the genus *Acmadenia*. Other species in *Acmadenia* with similar open flowers and small staminodes are *A. matroosbergensis* and *A. teretifolia*. Factors excluding this plant from other genera of the *Diosmeae* are: (1) petals without any transverse beard; (2) staminodes present; (3) anther with a small apical gland; (4) stigma capitate; (5) style short; (6) filament and style glabrous.

It is interesting to note the way in which the base of the leaf is closely addressed to the branch around its point of attachment, reminding one of a parasitic scale insect. *Acmadenia patentifolia* is recognised as distinct on account of having very small, thick, alternate leaves, small open flowers and a large fruit with long horns. It looks rather like *A. tetracarpellata* which however has somewhat thinner, opposite leaves and a four-carpellate fruit.

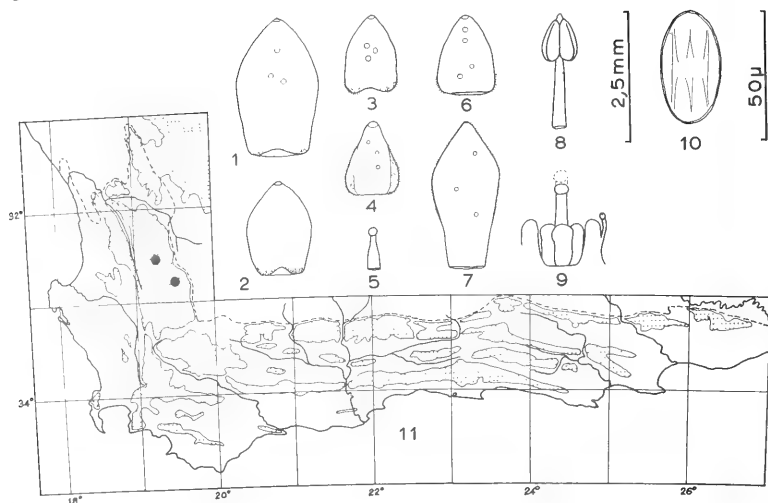


FIG. 8.

Acmadenia patentifolia: 1, leaf. 2, leaf. 3, bract. 4, bracteole. 5, staminode. 6, calyx lobe. 7, petal. 8, anther. 9, gynoecium with section of disc. 10, pollen. 11, distribution.



FIG. 9.

Acmadenia patentifolia showing disc, staminodes etc.

Acmadenia kiwanensis Williams, sp. nov. propria propter folia alterna lanceolata acuta puberula apicibus minute echinulatis, bracteolas nullimodo apiculatas, fructum aliquantum pubescentem sepala magnopere excedentem.

Frutex 300–500 mm, ad basin monocalis. *Rami* patentes, subnumerosi, glabri. *Ramuli* aliquanto numerosi, erecti, albopuberuli. *Folia* 7–14 mm longa, 2,2–1,5 mm lata, lanceolata vel lineari-lanceolata, acuta, petiolata, glanduloso-punctata, puberula, alterna, patentes, apicibus minute echinulatis, marginibus initio ciliolatis. *Inflorescentia* solitaria, terminalis, 10 mm diam., roseus. *Bractea* 4 mm longa, 1,5 mm lata, oblonga, acuta, glabra, ad basin translucens. *Bracteolae* duae, 3,5 mm longae, 2 mm latae, lanceolatae, acutae, ciliatae, glabrae, ad basin translucens. *Sepala* quinque, 3 mm longa, 2 mm lata, ovato-lanceolata, acuta, glabra, villosa-ciliata, intus in medio pubescentia. *Petala* quinque, in toto 6 mm longa; *limbus* 2,5 mm lata, obovatus, apiculatus, glaber, roseus, recurvus; *unguis* 3 mm longus, 1,2 mm latus, pubescens. *Staminodia* quinque, 1 mm longa, erecta, glabra, ad apice glandulosa. *Filamenta* quinque, post anthesin 2,5 mm longa, acicularia. *Antherae* quinque, 1,5 mm longae, 0,8 mm latae, flavovirentia, apicibus glandulosi. *Pollen* 40 μ longum, 33 μ latum. *Discus* erectus, breviter ovarium excedens, viridus. *Stigma* 0,7 mm diam., viridum, capitatum. *Stylus* 2 mm longus, erectus, glaber. *Ovarium* 5-carpellatum, 0,8 mm diam., sparsim pubescens. *Fructus* 5-carpellatus, 6,5 mm longus, 4,5 mm diam., aliquantus pubescens, sepala magnopere excedens, cornibus c. 1,5 mm longis. *Semen* 4,5 mm longum, 1,9 mm latum, piceum, nitens.

Type: CAPE—3327 (Peddie): on right hand side of road to Kiwane, 2,6 km from main Peddie/East London road (-BA), 122 m (400 ft.) alt., 9/3/1976, Williams 2175 (NBG, holotype; BOL, GRA, K, MO, NSW, PRE, S, isotypes).

Acmadenia kiwanensis was apparently collected for the first time by an Agricultural Officer in the Native Affairs Department in 1952 who noted that it was "prevalent between Keiskamma and Chalumna Rivers within five miles of the coast". Comins found it again in 1956 on "south west facing slopes above Kiwani River". Samples of their material, preserved at both Pretoria and Grahamstown, looked rather different from any other known *Acmadenia* and the locality was so much further to the east than that of any other member of the genus, that it became imperative for this plant to be further investigated by the collection of fresh material. The collection of fresh material on a field trip of some 2 260 km resulted in the publication of this description.

Shrubs 300–500 mm tall, single stemmed at base. *Branches* fairly numerous, almost sprawling (perhaps due to trampling by cattle), greyish-brown, glabrous. *Branchlets* fairly numerous, erect, somewhat clustered, not hidden by the leaves, at first densely clothed with short white erect hairs. *Leaves* 7–14 mm long including the petiole 1–1,5 mm long, 2,2–1,5 mm broad, the longest being narrower, lanceolate to linear-lanceolate, acute, 5-ranked, alternate, reading,

uppermost erect at first; apex pale minutely bristly; margins scabrid, at first ciliate becoming virtually eciliate; abaxial surface with gland dots small and numerous scattered between midrib and margins, pubescent with short erect hairs mainly towards the margins and midrib. *Inflorescence* solitary, terminal, 10 mm diam., pink, subtended by several bract-like leaves. *Bract* 4 mm long, 1,5 mm broad, oblong, acute, glabrous or puberulous, petiolate. *Bracteoles* two, 3,5 mm long, 2 mm broad, lanceolate, acute, puberulous above, ciliate, broadly translucent below. *Calyx lobes* five, 3,5 mm long, 2 mm broad, ovate-lanceolate, puberulous above; apex acute green, elevated; margins ciliate, broadly translucent and villous ciliate below; adaxial surface pubescent in the middle. *Petals* five, 6 mm long overall; *limb* 2,5 mm broad, obovate, apiculate, glabrous, pink, spreading; *claw* 3 mm long, 1,2 mm broad, narrowing to the base, pubescent and bulged inwards at the throat. *Staminodes* five, 1 mm long, erect, glabrous, gland-tipped. *Filaments* five, becoming 2,5 mm long erect, glabrous, acicular. *Anthers* five, 1,5 mm long, 0,8 mm broad, greenish-yellow, apical gland pointed and minute. *Pollen* 40 μ long, 33 μ broad, broadly elliptic. *Disc* fleshy, green, erect, just exceeding the ovary. *Stigma* 0,7 mm diam., green, capitate. *Style* becoming 2 mm long, glabrous, ever-erect. *Ovary* 5-carpellate, 0,8 mm diam., somewhat pubescent at the sides of the carpels. *Fruit* 5-carpellate, 6,5 mm long, 4,5 mm diam.; *carpels* green, minutely gland-dotted, short-pubescent mainly at the sides; *horns* 1,5 mm long, erect, apex cleft adaxially. *Seed* 4,5 mm long, 1,9 mm diam., black, shining, endosperm black-covered.

SPECIMENS EXAMINED

CAPE—3327 (Peddle): prevalent between Keiskamma and Chalumna rivers, within 5 miles of coast (-BA), -/8/1952, *C.A.O. Native Affairs Dept. A1906* (GRA, PRE); S.W. facing slope above Kiwane river 18/5/1956, *Comins 1522* (GRA, PRE); on right hand side of road to Kiwane, 2,6 km from the main Peddie/East London road 122 m (400 ft.), 9/3/1976, *Williams 2175* (NBG, BOL, GRA, K, MO, NSW, PRE, S).

DISTRIBUTION AND BIOLOGY

Acmadenia kiwanensis, so far as is known, occurs only between the Keiskamma and Chalumna rivers within 8 km of the coast. It grows in relic fynbos surrounded by mixed grassveld in shallow soil on flat quartzitic sandstone. The surrounding area is fairly heavily grazed by cattle and frequently burnt off. The plants appear to have been trodden down at some time but have lately escaped burning. It is doubtful if they could survive veld fires as there is no evidence of a persistent rootstock such as is possessed by *Agathosma peglerae*, a plant which occurs nearby in the recently burnt grassveld. One or two ripe fruits having been seen early in March, indicate that flowering had been taking place some months earlier and material collected some time in August was also still flowering. From

this it would appear that flowering must extend over a considerable part of the year. The pink flowers and nectariferous disc indicate that this plant is most probably pollinated by insects. Regeneration is from seed which is ejected when ripe in the usual way by a catapult mechanism. The leaves, when crushed, have a pleasant sweet smell faintly approaching that of aniseed.

DISCUSSION

This plant is placed in the genus *Acmadenia* because of having clawed petals, pubescent and bulging inwards at the throat, staminodes 1 mm long and an obvallate disc, i.e. that exceeds and surrounds the ovary but does not spread outwards or close over it.

Characters that exclude other genera of the *Diosmeae* are: (1) *style and filaments* glabrous and short; (2) *anthers* with a small apical gland; (3) *fruit* 5-carpellate.

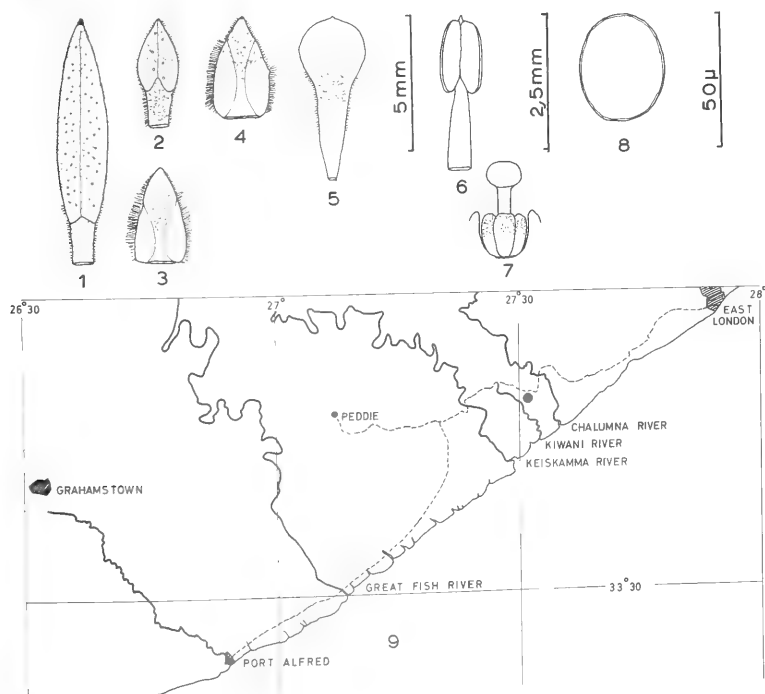


FIG. 10.

Acmadenia kiwanensis: 1, leaf. 2, bract. 3, bracteole. 4, calyx lobe. 5, petal. 6, anther. 7, gynoecium with section of disc. 8, pollen. 9, distribution.

Acmadenia kiwanensis is recognised as distinct on account of its having alternate, lanceolate-acute, puberulous leaves with the tips pale and minutely bristly, fruits somewhat pubescent with fairly short horns and imbricated only towards the base by the calyx lobes. Geographically the nearest species in the same genus is *A. obtusata* (Thunb.) B. & W., about 200 km to the south west, near to Port Elizabeth, growing on limestone, with leaves nearly always opposite, with bracts and bracteoles apiculate and with fruits glabrous, short horned and more or less hidden by the calyx lobes. Further to the west beginning near Plettenberg Bay *A. alternifolia* can be readily distinguished by its fruits with much longer horns.

Acmadenia nivea Williams, sp. nov. propria propter folia lanceolata glabra, petala nivea, staminodia 0,09–0,5 mm variantia, antheras minute \pm sessili-glanduliferas, ovarium 3 vel 4-carpellatum, cornibus binatim perbrevibus.

Frutex 200–300 mm, graciles, diffusus, ad basin monocaulis. *Rami* pauci, laxiusculi, glabrescenti, porphyrei, sparsim 2-chotomi. *Ramuli* pauci, graciles, erecti, sparsim puberuli, porphyrei. *Folia* 6–8 mm longa, 1,5–1,8 mm lata, lanceolata, acuta, rubro-mucronata, brevi petiolata, glabra, bifaria glanduloso-punctata, adpressa vel sub-patentia, alterna vel interdum ad basin opposita, marginibus late translucentibus ciliatis vel eciliatis. *Inflorescentia* terminalis, ad 7-aggregata; *flos* 6 mm diam., sessilis, niveus, fauce contractus. *Bractea* 2,7–5 mm longa, 0,7–1,3 mm lata, extima folio simili, intima lanceolata, rubro-mucronata, glabra, glanduloso-punctata, sessilia, marginibus ad basin late translucentibus ciliolatis. *Bracteolae* duae, 2,3 mm longae, 0,6 mm latae, lanceolatae, rubro-mucronatae, ciliolatae, marginibus ad basin translucentibus. *Sepala* quinque, 2,8–3 mm longa, 1,5 mm lata, elliptica, glabra, ciliata, rubro-mucronata, marginibus late translucentibus. *Petala* quinque, 5 mm longa; *limbus* 1,8 mm latus, ellipticus, glaber, nivea, patens; *unguis* glaber, translucens, ciliolatus vel eciliolatus. *Staminodia* quinque, 0,09–0,5 mm longa variantia, vestigialia. *Filamenta* quinque, post anthesin 1 mm longa, glabra, acicularia, erecta. *Antherae* quinque, ante anthesin 0,9 mm longae, 0,6 mm latae, vinosae, minute glanduliferae. *Stigma* 0,3 mm diam., viridum, capitatum. *Stylus* 0,5 mm longus, glaber, erectus. *Ovarium* 3 vel 4-carpellatum, 0,5 mm diam., globosum, glabrum; *carpellum* ad apicem bifidum. *Fructus* 3 vel 4-carpellatus, breve pedicellatus, 3,5 mm longus, glaber; *cornibus* binatim, perbrevibus. *Semen* 2,3 mm longum, 1,5 mm latum, ovoideum, piceum, nitens.

Type: CAPE—3418 (Simonstown): marshy ground, peaty soil, amongst restiads, Steenbras catchment area, Kogelberg, Caledon Division (-BB), 1 265 m (4 150 ft.), 13/6/1975, Williams 2006 (NBG, holotype).

Acmadenia nivea was first discovered by T. Stokoe in August 1924 on the Kogelberg. He also found it on the top of Somerset Sneeuwkop in 1937. Being a

rare plant it has been very seldom seen and very little material has been distributed.

Shrubs 200–300 mm tall, slender, diffuse, branching from a single stem at base. *Branches* few, somewhat lax, glabrescent, reddish-brown, sparingly dichotomous. *Branchlets* few, slender, erect, sparsely puberulous, reddish-brown. *Leaves* 6–8 mm long, 1.5–1.8 mm broad, lanceolate, acute, rubro-mucronate, short-petiolate, glabrous, with 2 rows of gland dots, adpressed or sub-spreading, alternate or at the base sometimes opposite; margins broadly translucent, thin, ciliate or eciliate. *Inflorescence* terminal, up to 7-aggregate; *flower* 6 mm diam., sessile, pure white, contracted at the throat. *Bract* 2.7–5 mm long, 0.7–1.3 mm broad, the outermost leaf-like, the inner becoming lanceolate, rubro-mucronate, glabrous, gland-dotted, sessile; margins towards the base broadly translucent, ciliolate. *Bracteoles* two, 2.3 mm long, 0.6 mm broad, lanceolate, rubromucronate, ciliolate; margins translucent below. *Sepals* five, 2.8–3 mm long, 1.5 mm broad, elliptic, glabrous, ciliate, rubro-mucronate; margins broadly translucent. *Petals* five, 5 mm long bent inwards at the throat; *limb* 1.8 mm broad, elliptic, glabrous, pure white, spreading; *claw* glabrous, translucent, ciliate above or eciliate. *Staminodes* five, varying from 0.09 mm to 0.5 mm vestigial, arising on the outside of the disc. *Filaments* five, becoming 1 mm long, glabrous, acicular, erect. *Anthers* five, 0.9 mm long, 0.6 mm broad before anthesis, wine coloured with a minute apical gland. *Stigma* 0.3 mm diam., depressed globose, green, capitate. *Style* becoming 0.5 mm long, glabrous, erect. *Ovary* 3-carpellate or (as in *Esterhuysen 15245*) 4-carpellate, 0.5 mm diam., globose, glabrous; *carpel* bifid at the apex. *Fruit* 3–4 carpellate, short-pedicellate, 3.5 mm long, glabrous; *horns* paired, extremely short. *Seed* 2.3 mm long, 1.5 mm broad, egg-shaped, black, shining.

SPECIMENS EXAMINED

CAPE—3418 (Simonstown): Kogelberg, near the summit, marshy areas, Caledon Division (-BB), 4 100 ft., -/8/1924, *Stokoe 968* (BOL), -/11/1944, *Stokoe s.n.* (BM, BOL, NBG, PRE, SAM 58809), 15/11/1964, *Esterhuysen 30644* (BOL), 7/5/1966, *Esterhuysen s.n.* (BOL), 15/4/1966, *Thompson 181* (PRE, STE), 21/4/1970, *Boucher 1244* (STE), 13/6/1975, *Williams 2006* (NBG); marshy areas between Kogelberg and Spinnekopnes, 31/9/1975, *Vogelpoel s.n. (Williams 2090)* (NBG); Somerset West Sneeuwkop, Caledon Division, 5 000 ft., 12/3/1937, *Stokoe 5016* (BOL, SAM 52244), 10/2/1957, *Esterhuysen 20764* (BOL); on rock or on steep rocky slopes on south side of Somerset West Triplets, Caledon Division, 4 800 ft., 10/4/1949, *Esterhuysen 15245* (BOL); Kogelberg Forest Reserve, north east slopes of Voorberg, Caledon Division (-BD), 550 m, 2/10/1971, *Boucher 1648* (STE).

DISTRIBUTION, BIOLOGY AND VARIATION

Acmadenia nivea is found only on the high peaks of the Hottentots Holland mountains 1 250 to 1 600 m (4 100–5 200 ft.) above sea level growing in marshy areas usually facing south to south east. It is an extremely rare plant, a few individuals only being found scattered amongst the vegetation. It is destroyed by fires and regeneration can only take place from seed. The brilliantly white petals must be attractive to insects and perhaps moths. The disc is fairly flat on top, dark green, fleshy and exudes nectar. It forms an annulus around and slightly above the unextended stigma while the pollen is being shed. The anthers remain below the contracted throat of the perianth. After the pollen is shed the style lengthens placing the receptive stigma on a level with the empty anthers. It would appear therefore that this plant is insect pollinated and that the reproductive parts of the flowers are well protected against the inclement weather usually experienced at these exposed altitudes.

There seems to be some evidence of variation in this species perhaps indicating a trend towards reduction. Populations from the Somerset Snееuwkop area have flowers with staminodes 0,4–0,3 mm long and ovaries with 4 to 3 carpels. Populations from the Kogelberg area have flowers with staminodes reduced to between 0,3 and 0,1 mm long and ovaries with 3 carpels. In the very closely related species, *A. candida*, the staminodes are reduced to a minute scale 0,05 mm in diameter and the ovary to only two carpels.

DISCUSSION

Although having an ovary with only 3–4 carpels instead of the more normal number of 5, this plant is placed in the genus *Acmadenia* because of having (1) petals clawed and bent inwards at the throat without any transverse beard; (2) staminodes present; (3) anthers with a small apical gland; (4) disc closing over the ovary; (5) stigma capitate; (6) style short, erect, glabrous; (7) filaments short, glabrous.

Acmadenia nivea is recognised as distinct on account of having glabrous, lanceolate leaves, snow white petals, staminodes varying from 0,09 to 0,5 mm long, anthers with minute \pm sessile apical glands and a 3–4 carpellate ovary. It is nearest to *Acmadenia candida*, a smaller plant, in which however the ovary is reduced to only two carpels. The name refers to the pure white petals.

Acmadenia candida Williams, sp. nov. propria propter fruticem gracillimum glaberrimumque, petala candida, staminodia mimima, antheras glanduliferas minute stipitatas, ovarium 2-carpellatum.

Frutex 250–300 mm, gracillimus, ad basin monocalis. *Rami* pauci, gracillimi, laevi, erecti, aphylli, porphyrei, 1–2 chotomi. *Ramuli* pauci, filiformi, brevis, sparsim foliosi. *Folia* 4–5 mm longa, 1 mm lata, lanceolata, glabra, sessilia, erecta, alterna, minute scabrido-mucronulata, bifaria glanduloso-punctata, sparsim

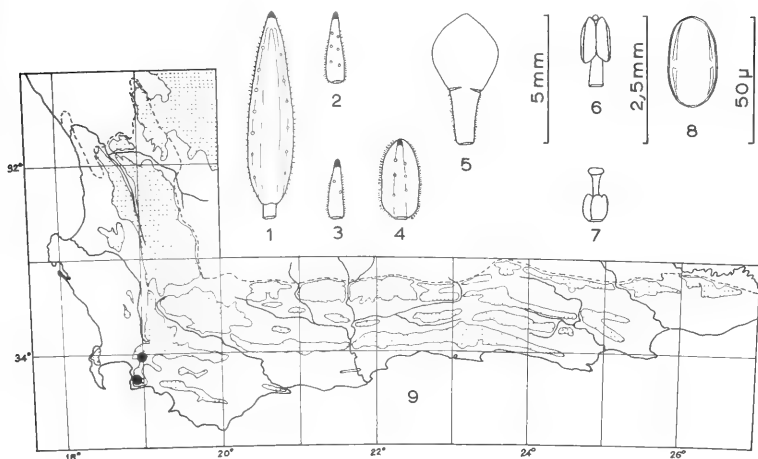


FIG. 11.

Acmadenia nivea: 1, leaf. 2, bract. 3, bracteole. 4, calyx lobe. 5, petal. 6, anther. 7, gynoecium. 8, pollen. 9, distribution.

ciliolata vel eciliata, marginibus late translucentibus. *Inflorescentia* terminalis, \pm 6-aggregata; *flos* 4 mm diam., candidus, fauce contractus. *Bractea* 1,7–2,3 mm longa, 0,6–0,8 mm lata, lanceolata, acuta, mucronulata, glanduloso-punctata, glabra, sparsim ciliolata, marginibus translucentibus. *Bracteolae* duae, 1,1 mm longae, 0,4 mm latae, lanceolatae, mucronulatae, glabrae, sparsim ciliolatae, marginibus translucentibus. *Sepala* quinque, 1,8 mm longa, 0,9 mm lata, ovato-lanceolata, mucronulata, glabra, sparsim glanduloso-punctata, ciliolata, marginibus late translucentibus. *Petala* quinque, 3,1 mm longa; *limbus* 2 mm diam., orbicularis, glaber, candidus, patens; *unguis* 1,1 mm longus, 0,7 mm latus, crispociliatus. *Staminodia* quinque, 0,05 mm diam., ultima vestigialia. *Filamenta* quinque, post anthesin 0,6 mm longa, glabra, erecta. *Antherae* quinque, ante anthesin 0,5 mm longae, 0,3 mm latae, vinosae, glanduliferae minute stipitatae. *Pollen* 28 μ longum, 17 μ latum, oblongum. *Stigma* 0,15 mm diam., capitellatum, globosum. *Stylus* 0,6 mm longus, glaber, erectus. *Ovarium* 2-carpellatum, \pm 0,3 mm diam., glabrum; *carpellum* ad apicem bifidum. *Fructus* et *semen* a nobis non visa.

Type: CAPE—3419 (Caledon): in a marsh on level area, top of road from Nuweberg Forest Station, mixed up with low dense Restionaceae, east slopes of Landdrost Kop, Caledon Division (-AA), 1 070 1 220 m (3 500–4 000 ft), 17/3/1968, Esterhuysen 31946 (BOL, holotype).

Acmadenia candida was discovered by T. Stokoe in 1943 growing on the east slopes of Landdrost Kop in the Hottentots Holland Mountains. It was not until 1968, after the Forestry Department had constructed a road up to the east slopes of Landdrost Kop, that Miss Elsie Esterhuysen again found this plant. Two months later she made another collection and subsequently the Forestry Department burnt the whole area off as a firebreak. Repeated searches in recent years have failed to reveal anything and now the Forestry Department, having declared this a "Wilderness Area", have constructed an enormous mountain chalet at the end of their access road. It is quite possible that this species is now extinct.

Shrubs 250–300 mm tall, slender, single-stemmed below. *Branches* few, extremely slender, smooth, erect, leafless, reddish-brown, 1–2 chotomous. *Branchlets* few, filiform, short, rather sparsely leafy, exoderm like snake skin splitting off, arising from immediately below the inflorescence. *Leaves* 4–5 mm long, 1 mm broad, lanceolate, scabrido-mucronulate, glabrous, 2-fariously gland-dotted, very sparsely ciliolate or eciliate, adpressed erect, alternate margins broadly translucent. *Inflorescence* terminal, up to 6-aggregate with flowers about 4 mm diam., pure white, contracted at the throat. *Bract* 1,7–2,3 mm long, 0,6–0,8 mm broad, lanceolate, acute, mucronulate, gland-dotted, glabrous, sparsely ciliolate, margins translucent. *Bracteoles* two, 1,1 mm long, 0,4 mm broad, lanceolate, mucronulate, glabrous, sparsely ciliolate, margins translucent. *Calyx lobes* five, 1,8 mm long, 0,9 mm broad, ovate-lanceolate, mucronulate, glabrous, gland-dotted, ciliolate, margins broadly translucent. *Petals* five, 3,1 mm long, clawed, bent inwards at the throat; *limb* 2 mm diam., orbicular, glabrous, spreading, pure white; *claw* 1,1 mm long, 0,7 mm broad, margins above shaggy ciliate. *Staminodes* five, 0,05 mm diam., an absolutely minute vestigial scale on the outside of the disc. *Filaments* five, becoming 0,6 mm long after anthesis, glabrous, erect. *Anthers* five, 0,5 mm long, 0,3 mm broad before anthesis, reddened with a minutely stipitate apical gland. *Pollen* 28 μ long, 17 μ broad, oblong with a rather thick skin. *Disc* closes over the ovary to some extent. *Stigma* 0,15 mm diam., globose, capitellate. *Style* becoming 0,6 mm long, glabrous, erect. *Ovary* 2-carpellate, \pm 0,3 mm diam.; *carpels* glabrous, bifid at the apex. *Fruit* and *Seed* not seen.

SPECIMENS EXAMINED

CAPE—3419 (Caledon): east of Landdrost Kop (-AA), -/4/1934, *Stokoe* 2845 (BOL); in a marsh on level area, top of road from Nuweberg Forest Station, east slopes of Landdrost Kop 3 500–4 000ft, 17/3/1968, *Esterhuysen* 31964 (BOL, holotype); in a marsh at east base of Landdrost Kop, Nuweberg Forest Reserve 3 000–3 500 ft, 18/5/1968, *Esterhuysen* 31961 (BOL).

DISTRIBUTION, BIOLOGY AND VARIATION

Acmadenia candida is apparently a very rare plant. As far as is known it occurred in only one locality on the eastern slopes of the Hottentots Holland

mountains at an elevation of about 1 070 m (3 500 ft) above sea level growing amongst low *Restionaceae* in a marsh. Flowering appears to extend from mid March to the middle of May. Fruiting material has not been seen. The conspicuous pure white flower with a constricted throat, may indicate that it is insect pollinated, perhaps by some small moth.

With so little material it is impossible to observe any variation but in this species we see an example of reduction carried to limits that may lead to extinction.

DISCUSSION

The characters that indicate that this plant should be placed in the genus *Acmadenia* and which exclude it from other genera of the *Diosmeae* are: (1) *petals* clawed, bent inwards at the throat without any transverse beard; (2) *staminodes* present on the outer surface of the disc although only vestigial; (3) *anthers* with a small apical gland; (4) *disc* closing over the ovary to some extent; (5) *stigma* capitellate; (6) *style* short, erect, glabrous; *filaments* short, glabrous. This species is unusual in that it shows almost complete reduction of its staminodes, in that the apical gland on the anther is minutely stipitate and in that the ovary is reduced to 2 carpels. These atypical characters do not really serve to place this species into either *Diosma* with no staminodes, *Adenandra* with stipitate anther glands or even into *Agathosma* which contains some 2-carpellate species.

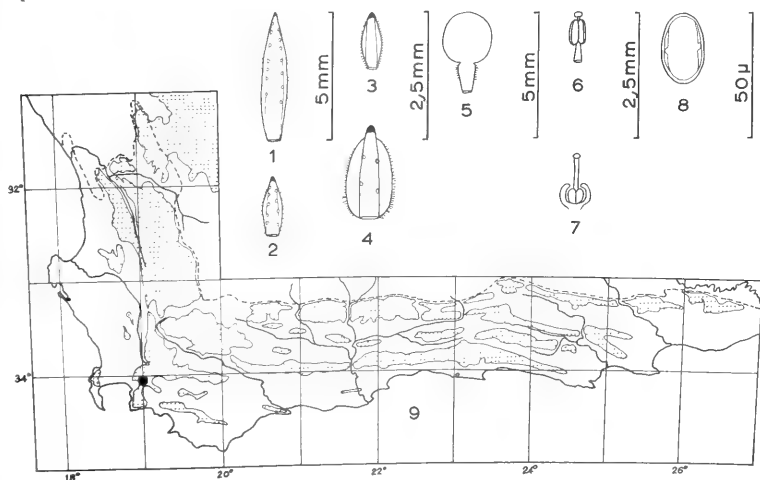


FIG. 12.

Acmadenia candida: 1, leaf. 2, bract. 3, bracteole. 4, calyx lobe. 5, petal. 6, anther. 7, gynoecium with section of disc. 8, pollen. 9, distribution.

Acmadenia candida is closest to *Acmadenia nivea* which however has staminodes somewhat less reduced and an ovary with 3 or 4 carpels.

Acmadenia candida is recognised as distinct on account of being an extremely slender glabrous plant with few branches, with white petals, with reduced staminodes, with anthers minutely stipitate-glandular and with a 2-carpellate ovary. The name alludes to the strikingly white petals.

Macrostylis ramulosa Williams, sp. nov. propria propter ramos ad basin ramulosos, folia lineari-lanceolata pubescentia ecostata, bracteas 2,5–4,5 mm longas pubescentes, bracteoles et sepalia ad apices pubescentes, fructum pubescentem.

Frutex inferior, 300 mm, sub-decumbens, ad basin monocalis. *Rami* sub-decumbentes, glabrescentes, ad basin ramulosi. *Ramuli* numerosi erectiusculi, foliosi, sparsim pubescentes. *Folia* 6–8 mm longa, 1,2 mm lata, lineari-lanceolata, acuta, erecta, sessiles, alterna, pubescentia, ecostata, indistincte glanduloso-punctata. *Inflorescentia* terminalis, 5–6 aggregata; *flos* 5 mm diam., albus. *Bractea* 2,5–4,5 mm longa, 0,8–1 mm lata, similis folio. *Bracteolae* duae, 1,6–2 mm longae, 0,6 mm latae, oblongae, sub-acutae, apicibus caespitosis, ad basin translucens. *Sepala* quinque, 3 mm longa, 1 mm lata, anguste lanceolata, ciliata, ad basin translucens, apicibus pubescentibus. *Petala* quinque, 5 mm longa, alba; *limbus* 1,4 mm latus, patens, sub-orbicularis; *unguis* 1,2 mm latus barbatus, eciliatus. *Staminodia* quinque, 0,3 mm longa, saepe vix visibilia. *Filamenta* quinque, post anthesin 6–7 mm longa, glabra. *Antherae* quinque, 1,2 mm longae, 0,7 mm latae, oblongae, flavidae, apicibus minute glandulosi. *Pollen* 52 μ longum, 22 μ latum, oblongum. *Discus* ovarium includens, stylus ad basin cingens, viridus, nectarifer. *Stigma* simplex, terminale. *Stylus* 6 mm longus, glaber. *Ovarium* 3-carpellatum, 0,6 mm longum, globosum, glabrum. *Fructus* (Williams 2261) 3-carpellatus, fere abortu 1-carpellatus, 12 mm longus, 3 mm latus, pubescens, rubro-glanduloso-punctatus, cornibus erectis, gracilibus. *Semen* 4,2 mm longum, 1,8 mm latum, arilatum, piceum, impositum.

Type: CAPE—3219 (Clanwilliam): north facing gravelly slopes, Middelberg Pass near Kleinplaas. Citrusdal (-CA), 777 m (2 550 ft.), 12/7/1975, Williams 2017 (NBG, holotype; BOL, K, M, MO, PRE, S, STE, isotypes).

Stokoe collected this plant twice during 1940 and thereafter again in 1945, 1950 and 1955. In spite of its rather distinct hairy appearance it has remained undescribed until now.

Undershrubs 300 mm tall, semi-decumbent, arising from a single stem almost below ground level. *Branches* tending to sprawl, glabrescent, greyish-brown, with small leaf scars. *Branchlets* numerous, fairly erect, sparsely pubescent, well clothed with leaves, many sprout from the older wood. *Leaves* 6–8 mm long, 1,2 mm broad, linear-lanceolate or subulate, incurved-erect, sessile, alternate, apex

pubescent and acute without any callus, ciliate almost without any hyaline margins; adaxial surface glabrous, concave; abaxial surface pubescent with scattered long hairs, round backed with many indistinct gland dots scattered mainly towards the midrib. *Inflorescence* terminal, 4–6 aggregate; flowers 5 mm diam., white. *Bract* 2.5–4.5 mm long, 0.8–1 mm broad, the inner smaller, similar to the leaf but with broad translucent margins towards the base. *Bracteoles* two, 1.6–2 mm long, 0.6 mm broad, oblong, apex sub-acute and tufted with bristly hairs, ciliate above, margins broad and translucent. *Calyx lobes* five, 3 mm long, 1 mm broad, narrowly lanceolate, apex a blunt hairy point, ciliate, margins translucent below. *Petals* five, 5 mm long, white; *limb* 1.4 mm broad, ovate, sub-acute, spreading; *claw* 1.2 mm broad, crisped-bearded above in the centre, eciliate. *Staminodes* five, 0.3 mm long, slender with a minute apical gland, arising at the outside base of the disc at the base of the petal, in many cases almost invisible. *Filaments* five, glabrous, becoming 6–7 mm long after anthesis. *Anthers* five, 1.2 mm long, 0.7 mm broad, yellow, oblong with a small apical gland. *Pollen* 52 μ long, 22 μ broad, oblong. *Disc* green, envelops the ovary, touching the base of the style, exudes nectar. *Stigma* simple, terminal. *Style* becoming 6 mm long, glabrous, pink at the tip. *Ovary* 3-carpellate, 0.6 mm diam., globose, glabrous. *Fruit* (from Williams 2261) 3-carpellate with normally only one carpel developing, 12 mm long, 3 mm broad, pubescent, reddish gland-dotted; *horns* 5 mm long, erect, slender. *Seed* 4.2 mm long, 1.8 mm broad, truncate with the aril extending 1.3 mm, black, matt.

SPECIMENS EXAMINED

CAPE—3219 (Clanwilliam): waterfalls between Citrusdal and Elandskloof (-CA), 3/8/1940, *Stokoe* 8181 (BOL); west end of Elandskloof above Citrusdal, 5/10/1946, *Esterhuysen* 13018 (BOL); Elandskloof, -/12/1940, *Stokoe* s.n. (SAM 58851), 26/3/1951, *Compton* 22696 (NBG), 27/8/1954, *Lewis* 4730 (SAM); north facing gravelly slopes, Middelberg Pass near Kleinplaas, Citrusdal, 777 m (2 550 ft.) 12/7/1975, *Williams* 2017 (NBG, BOL, K, M, MO, PRE, S, STE); Cedarberg, Duivelskop, 2 500–3 500 ft., -/1/1945, *Stokoe* s.n. (BOL, SAM 58812); Duivelskloof, -/9/1950, *Stokoe* s.n. (SAM 64158).

DISTRIBUTION AND BIOLOGY

Macrostylis ramulosa has been found only in a fairly small area, about 12 km in length, in the mountains to the east of Citrusdal in the Clanwilliam Division. It grows on gravelly-sandy soil derived from the Table Mountain series at altitudes of around 777 m (2 500 ft.) on north facing slopes. Flowers have been seen from March to September and fruits in December and January.

The disc exudes nectar which rises between the lower parts of the style and the filaments by capillary action. The small flowers are made more obvious by being aggregated into groups of 4 to 6. By the time that the anthers shed their pollen

they have been carried far beyond the throat of the flower and likewise, at a later stage when all the pollen has been shed, the style with the receptive stigma protrudes a long way. With the above facts in mind it would appear therefore that this plant is insect pollinated. Regeneration after fires seems to take place only from seed and not at all by coppicing from the root. The leaves have a very faint smell of cedar when crushed.

DISCUSSION

This species falls quite naturally into the genus *Macrostylis* of Bartling and Wendland. The following characters, besides being typical of the genus, also help to exclude it from some other genus of the *Diosmeae*: (1) *heads* up to 6 aggregate; (2) *petals* with a dense shaggy pubescence at the throat; (3) *staminodes* vestigial, at most 0,3 mm long; (4) *anthers* with a minute apical gland; (5) *disc* closes over the ovary almost touching the base of the style; (6) *stigma* simple; (7) *style* and *filament* glabrous, protruding a long way; (8) *ovary* 3-carpellate.

Macrostylis ramulosa is recognised as distinct on account of being a semi-decumbent shrub with many branchlets sprouting towards the base, with linear-lanceolate pubescent leaves without any prominent midrib, with pubescent bracts 2,5–4,5 mm long, with bracteoles and calyx lobes pubescent at their tips, and with the fruit pubescent. It is nearest to *M. decipiens* which is a much more glabrous plant with the ability to coppice from the root after fires

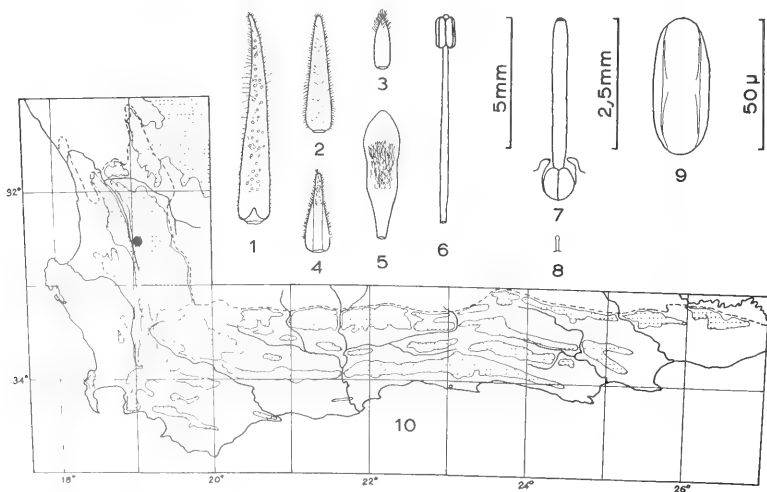


FIG. 13.

Macrostylis ramulosa: 1, leaf. 2, bract. 3, bracteole. 4, calyx lobe. 5, petal. 6, anther. 7, gynoecium with section of disc. 8, staminode. 9, pollen. 10, distribution.



FIG. 14.

Macrostylis ramulosa showing bearded petals and protruding filaments.

Acmadenia wittebergensis (Compton) Williams, comb. nov.

Diosma wittebergensis Compton in *Trans.R.Soc.S.Afr.* **19**:3: 297 (1931).
Type: 3320 (Montagu): Witteberg (Whitehill), south slope, Laingsburg Division (-BC), 1 067 m (3 500 ft.), 11/8/1924 *Compton 2524* (BOL, lectotype).

This plant was discovered by Professor R. H. Compton during the period 1923 to 1929 when he was making collections, in the vicinity of the Karoo Garden at Whitehill near Matjiesfontein, for his "Flora of the Whitehill District". Late in 1974 E. G. H. Oliver found the same plant on the Roodeberg in the Little Karoo near Ladismith. Examination of this material conveyed the impression that this species might be more satisfactorily placed in *Acmadenia* and fresh material was therefore collected (*Williams 2132*) to be used as the basis for the following description.

Shrubs up to 500 mm tall with many stems arising from a persistent rootstock.

Branches erect, stiff, 2–3 chotomous; *bark* greyish-brown, rough with leaf scars. *Branchlets* erect, stiff, short, puberulous, brownish, 2–3 chotomous, leafy. *Leaves* 11–13 mm long including petiole 1.5 mm long, 1.6–1.9 mm broad, linear-lanceolate, incurved-erect, alternate, crowded, loosely imbricate; adaxial surface, lower part of abaxial surface and petiole all puberulous; abaxial surface rounded, lumpy with two rows of gland dots, scabrid above; apex tapering to a pungent mucro; base narrowing to a short decurrent petiole; margins rounded, scabrid-ciliate. *Inflorescence* terminal, \pm 5 aggregate in a much reduced raceme of which several flowers may abort, base somewhat surrounded by the uppermost leaves; *flowers* 9 mm diam., white, opening in succession, crowded. *Bract* one to each flower, 2.5–4.5 mm long, uppermost shortest, 1 mm broad, lanceolate-subulate, incurved, with a pungent mucro, erect-pubescent on all sides, round-backed with 2 rows of gland dots. *Bracteoles* two, 1 mm long, 1.1–1.3 mm broad, deltoid-orbicular, obtuse, 2–4 gland-dotted, pubescent on both surfaces, margins shaggy-ciliate. *Calyx lobes* five, 2.5–2.7 mm long, 1.6–2 mm broad, broadly lanceolate, acute with a small mucro, pubescent on both surfaces, obscurely gland-dotted, shaggy-ciliate, reddish. *Petals* five, 5.8 mm long, 2.7–2.9 mm broad, elliptic, white, glabrous, recurved, 7 gland-dotted in 2 rows, margins irregularly serrate, clawed. *Staminodes* five, 0.5 mm long, conical, spreading-erect, arising close to the petal on the perimeter of the disc. *Filaments* five, becoming 1.5 mm long, glabrous, acicular, incurved. *Anthers* five, before anthesis 1.3 mm long overall, 0.9 mm broad, very dark red, produced upwards into a thickish support to the apical gland which produces an exudate before the bud opens. *Pollen* 40 μ long, 30 μ broad, sub-spherical. *Disc* thick, purplish, minutely pitted, sinuate, almost level equalling and closely surrounding the ovary, exudes nectar. *Stigma* 0.3 mm diam., globose, capitate, very dark red. *Style* becoming 1.2 mm long, glabrous, persisting, slightly deflexed. *Ovary* 5-carpellate, 1 mm long, 1.2 mm diam., glabrous; apices glandular-globose. *Fruit* 5-carpellate, 8 mm long, 9 mm diam., green with purplish tips, multi-gland-dotted; *horns* extremely short, truncate, apex emarginate clasping an immersed gland; *calyx lobes* persisting. *Seed* 6 mm long, 2.8 mm broad, black, shining, aril large and white.

SPECIMENS EXAMINED

CAPE—3320 (Montagu): Witteberg (Whitehill), south slope Laingsburg Division (-BC), 3 500 ft., 11/8/1924, *Compton* 2524 (BOL); Witteberg, summit, 5 000 ft., 21/5/1925, *Compton* 2951 (BOL); Witteberg near Whitehall, north slope, 4 000 ft., 24/10/1943, *Compton* 15248 (BOL, NBG); Anysberg, rocky north slopes, 3 000–3 500 ft., 19/4/1941, *Stokoe* 8187 (BOL, PRE, NBG, SAM 56858), 20/5/1972, *Esterhuysen* 32860 (PRE); Anysberg, south slopes (-DA), 2 500 ft., 2/8/1956, *Wurts* 1418 (NBG); Touwsberg, ridge on south slopes (-DB), 3 000–4 000 ft., *Esterhuysen* 25884 (BOL, NBG); Prinspoortberg, Little Karoo (-BD), 4 000 ft., -/7/1937, *Levy* 6159 (SAM).

—3321 (Ladismith): ridge between Rooiberg and Bailey Peak (-CB), 4 500 ft., 11/11/1974, *Oliver 5429* (STE, PRE); Bailey Peak, Rooiberg, north slopes, 4 300/4 800 ft., 2/11/1975, *Williams 2132* (NBG).

DISTRIBUTION AND BIOLOGY

Acmadenia wittebergensis has been found at altitudes of from 900–1 500 m (3 000–5 000 ft.) above sea level growing on dry rocky slopes in quartzitic soil derived from the Witteberg and Table Mountain series. The distribution is discontinuous with populations, showing little or no variation, situated on isolated quartzitic mountains. The surrounding land consisting of softer shales of the Bokkeveld series has been weathered down to much lower levels. As one cannot imagine any method of dispersal which could possibly bridge these gaps at the present time, one is forced to the conclusion that this species, in its present form, may have been in existence for a very long time. Plants from the Rooiberg seem to have leaves with long sharp points. The conspicuous white petals in the flower heads and the presence of nectar indicate that this plant is most probably insect pollinated. The seeds when ripe are ejected from the capsule by the usual catapult mechanism but regeneration after fires would appear to take place mainly by regrowth from a persistent rootstock. One fairly large plant, with about 50 stems, showed at least four episodes in the branching at the base indicating four past

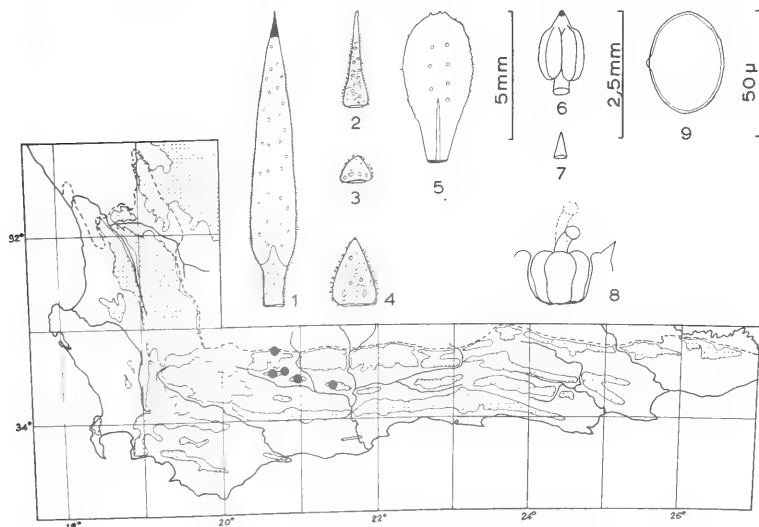


FIG. 15.

Acmadenia wittebergensis: 1, leaf. 2, bracteole. 3, bracteole. 4, calyx lobe. 5, petal. 6, anther. 7, staminode. 8, gynoecium with section of disc. 9, pollen. 10, distribution.

destructions by fire. A vigorous young branchlet, springing from the base, may be quite long, densely clothed with leaves and bear a cluster of twelve flowers at the apex. The flowers are sweet smelling. The leaves have a resinous smell when crushed and the fruits a smell of celery when crushed.

This plant has been transferred to the genus *Acmadenia* because of having its petals clawed (the claws more or less form a tubular perianth 4 mm long above which the blades of the petals bend outwards), also because of having pointed staminodes and a pointed gland at the apex of each anther; the disc does not spread widely with a crenulate margin as in *Diosma* but surrounds the ovary rather closely and is almost level on top. Other factors which exclude *Acmadenia wittebergensis* from other genera of the *Diosmeae* are: (1) *petals* without any beard; (2) *stigma* capitellate; (3) *style* and *filaments* short and glabrous; (4) *ovary* 5-carpellate.

Acmadenia wittebergensis is recognised as being distinct because of having thick pointed crowded leaves, pubescent bracts, bracteoles and calyx lobes, short conical staminodes with conical glands on the anthers and a multi-stemmed habit. It appears to have no very close resemblance to any other species of *Acmadenia*. At best one may say that it is nearest to *A. teretifolia* which Phillips also transferred to *Diosma*.

HABITAT OF THREATENED SPECIES OF *SERRURIA* AND *PROTEA* ENDEMIC TO WESTERN CAPE COASTAL FLATS

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ABSTRACT

The habitats of four species of *Serruria* and two species of *Protea*, all threatened endemics in Coastal Fynbos and Coastal Rhenosterbosveld, are described. These habitats are compared with those of other threatened species of Proteaceae and Restionaceae.

UITTREKSEL

HABITAT VAN BEDREIGDE *SERRURIA* EN *PROTEA* SPESIES ENDEMIES AAN DIE WESTELIKE KAAPSE KUSVLAKTES

Die habitate van vier *Serruria* spesies en twee *Protea* spesies word beskryf en vergelyk met die habitate van ander Proteaceae en Restionaceae spesies. Hierdie bedreigde spesies kom met beperkte verspreidings in kusfynbos en kusrenosterbosveld voor.

INTRODUCTION

Several recent papers have described the habitats of rare and threatened species of Proteaceae and Restionaceae on the western Cape coastal flats (Milewski & Esterhuysen, 1977; Milewski, 1977, Milewski, 1978). This paper describes the habitats of six additional threatened species of Proteaceae, in relation to those of the species previously dealt with in this way. Knowledge of the habitats of threatened species is an urgent prerequisite for their conservation.

METHODS

Six species were chosen for study, each restricted to a small geographical range of less than 700 km² on the western coastal flats of the south-western Cape (Milewski & Esterhuysen, 1977; Milewski, 1978). The study species were *Serruria triloph*a Knight, *S. linearis* Salisb. ex Knight, *S. furcellata* R. Br., *S. cyanoides* R. Br., *Protea odorata* Thunb. and *P. mucronifolia* Salisb. All are evergreen perennials. *Protea odorata* and *P. mucronifolia* grow as 0.5-0.8 m high, single-stemmed, firm woody shrubs (caespitose nanophanerophytes). The *Serruria* species grow as shrublets (chamaephytes) arising from a small lignotuber at ground level as a number of sparsely branched lax stems to a height of 0.2-0.7 m, lowest for the sprawling *S. triloph*a.

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Accepted for publication 16th March, 1978.

Methods were similar to those used by Milewski (1978). The thoroughness of the investigation was severely limited by the study species' relict status. All known remaining populations were investigated, "populations" of a species being arbitrarily defined as stands farther than 2 km apart (Milewski & Esterhuysen, 1977; Milewski, 1978). Data were recorded from two populations of all species except *S. furcellata* and *S. cyanoides* (only one population of each evidently remains), and *S. linearis* (three populations). The substrate, and the physiognomy and general floristics of vegetation, associated with each population were subjectively recorded. All associate species in the Proteaceae and Restionaceae (Milewski, 1978), growing within 0.5 m of the study species, were listed. This was done for each of a minimum total of 50 study plants scattered throughout each population except for *S. furcellata*, of which only 25 plants could be found.

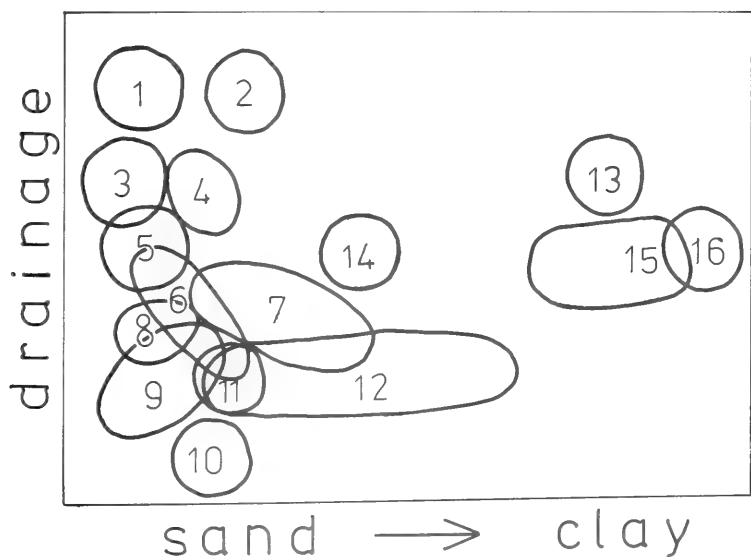


FIG. 1.

The western Cape coastal flats, showing distribution of *Protea odorata* (O), *P. mucronifolia* (M), *Serruria trilophophylla* (T), *S. linearis* (L), *S. furcellata* (F) and *S. cyanoides* (C) in relation to biotic areas. Localities were plotted using a twelfth-degree grid. Each symbol represents the occurrence of the species within a square corresponding to one-ninth of the area of a quarter-degree grid-square (smaller versions of the symbols were used where two species were recorded in the same grid-square). See Milewski and Esterhuysen (1977) and Milewski (1977) for explanation of biotic areas.

Serruria trilophata, *S. linearis* and *S. furcellata* are associated with adjacent areas of pale, leached Quaternary sand (Table 1, Figs 1 & 2). This sand occurs as a mantle of variable depth on flat to gently sloping landscapes (Table 1). The associated vegetation is Coastal Fynbos (Table 1).

Herbarium labels indicate that *S. cyanoides* formerly occurred at altitudes between 30 m and 550 m “on hill slopes and on flats”. Collection sites include “dunes” at the lowest altitudes and “sandy south-east slopes” of mountains at the highest altitudes. *Serruria cyanoides* is today known only from aeolian sand covering a gently sloping saddle on the mid-altitude slopes of a coastal mountain (Table 1). The associated Coastal Fynbos differs from that associated with *S.*



Diagrammatic representation of the habitats of 16 threatened species of Proteaceae and Restionaceae on the western coastal flats of the south-western Cape excluding the Breërivier Valley, drawn subjectively on the basis of data on associates in the Proteaceae and Restionaceae, and observation of substrates. 1 = *Serruria trilophia*, 2 = *S. cyanoides*, 3 = *S. linearis*, 4 = *S. furcellata*, 5 = *Chondropetalum acockii*, 6 = *S. ciliata*, 7 = *Elegia prominens*, 8 = *Restio micans*, 9 = *Leucadendron levisanum*, 10 = *L. floridum*, 11 = *Restio sabulosus*, 12 = *E. verreauxii*, 13 = *Protea mucronifolia*, 14 = *Diastella buekii*, 15 = *Protea odorata* and 16 = *L. verticillatum*. Overlapping areas indicate that the species coexist in part of their habitat as associates (Milewski & Esterhuysen 1977; Milewski 1977, 1978). *Thamnochortus fraternus*, a species of well-drained, neutral to alkaline sand, was omitted.

trilopha, *S. linearis* and *S. furcellata* (Tables 1 & 2). The presence of *Thamnochortus erectus* and *Leucadendron coniferum* (Table 2) suggests that the associated sand is younger and less leached than that on which the other *Serruria* species grow (Taylor, 1969; Boucher, 1972; Milewski, 1977). This substrate is usually found elsewhere as eroded sublittoral dunes (Taylor, 1969).

The communities of Restionaceae and Proteaceae associated with *S. trilopha* and *S. linearis* were 46,1 % similar to each other, whereas they were respectively only 20,3 % and 12,5 % similar to that associated with *S. cyanoides*. These figures were calculated on the basis of the Czekanowski coefficient following Milewski (1978). This supports the suggestion that the habitat of *S. cyanoides* is distinct from those of the other study species of *Serruria*.

Protea odorata and *P. mucronifolia* are also allopatric (Fig. 1). Both occur on clay-rich soil on flats and gentle slopes (Table 1, Fig. 2). The associated vegetation is a form of Coastal Rhenosterbosveld (Table 1, Fig. 1). The associated communities of Restionaceae and Proteaceae (Table 3) were 30,3 % similar between the two species, on the basis of the Czekanowski coefficient (following Milewski, 1978). This suggests that the habitat of *P. odorata* is distinct from that of *P. mucronifolia* (Milewski & Esterhuysen, 1977; Milewski, 1977) despite the apparent similarity of the associated climate and substrate.

The habitats of *S. trilopha*, *S. linearis* and *S. furcellata* may be compared with those of partly sympatric threatened species also occurring on sand (Milewski & Esterhuysen, 1977; Milewski, 1977, 1978). These species, including the congener *S. ciliata*, grow under conditions of poorer drainage than the present study species (Fig. 2). The habitats of *P. odorata* and *P. mucronifolia*, compared in the same way, are similar to that of *Leucadendron verticillatum* (Fig. 2).

ACKNOWLEDGEMENTS

I wish to thank Professor E. A. C. L. E. Schelpe for the use of facilities at the Bolus Herbarium, University of Cape Town. The study was supervised by Dr A. V. Hall, project leader of the Rare and Endangered Plant Species Research Group, and supported by the National Programme for Environmental Sciences. Miss E. Esterhuysen and Dr J. P. Rourke kindly assisted with identification of Restionaceae and Proteaceae respectively. An initial herbarium survey of endemic species was undertaken by Mrs M. Bates, Miss G. M. van Niekerk and Miss G. M. Micklem. I am grateful to Mrs M. L. Jarman, Mrs D. Jones and Miss C. Davidge for typing the manuscript.

REFERENCES

- BOUCHER, C., 1972. *The vegetation of the Cape Hangklip area*. M.Sc. thesis. Cape Town: University of Cape Town.
- MILEWSKI, A. V. and ESTERHUYSEN, E., 1977. Habitat of Restionaceae endemic to western Cape coastal flats. *Jl S. Afr. Bot.* **43**: 233–241.

- MILEWSKI, A. V., 1977. Habitat of Restionaceae endemic to the south-western Cape coastal flats. *Jl S. Afr. Bot.* **43**: 243-261.
- MILEWSKI, A. V., 1978. Habitat of threatened Proteaceae endemic to western Cape coastal flats. *Jl S. Afr. Bot.* **44**: 55-65.
- TAYLOR, H. C., 1969. *Vegetation of the Cape of Good Hope Nature Reserve*. M.Sc. thesis. Cape Town: University of Cape Town.
- TAYLOR, H. C., 1978. Phytogeography and ecology of Capensis. In: M. J. A. Werger (ed.), *Biogeography and Ecology of Southern Africa*. The Hague: Junk.

TABLE 1
Vegetation and environment associated with study species of *Serruria* and *Protea*

Study species	Description of vegetation		Substrate and locality
	General	Detailed	
<i>S. trilophia</i>	Scattered plants in a mainly restioid-ericeid (<i>sensu</i> Taylor, 1978) Coastal Fynbos, 0.4–1.5 m high, with 65–75 % projective foliage cover	<p>(i) A main 0.5 m stratum of tufted restioids (<i>sensu</i> Taylor, 1978) (e.g. <i>Thamnochortus punctatus</i>) and ericeid shrubs (<i>Phyllica cephalantha</i>, with e.g. <i>Cliffortia falcata</i>, <i>Lachnaea capitata</i>, <i>Cryptadenia grandiflora</i>, <i>Suaavia radiata</i>, <i>Diosma oppositifolia</i>, <i>Sylapieris fruticosus</i> and <i>Phyllica stipularis</i>; a sparse ground stratum of forbs (e.g. <i>Helichrysum indicum</i>), wiry restioids (e.g. <i>Leptocarpus vimineus</i>), grasses (e.g. <i>Ehrharta ramosa</i>), sedges (e.g. <i>Ficinia deusta</i>), succulents (e.g. <i>Lampranthus amoenus</i>) and the creeping shrub <i>Leucospermum hypophyllocarpodendron</i>; scattered proteoid (<i>sensu</i> Taylor, 1978) and ericeid shrubs (e.g. <i>Protea pulchra</i>, <i>Erica mammosa</i>) emergent to 1.0 m</p> <p>(ii) Similar to the above; conspicuous plants included <i>Suaavia radiata</i>, <i>Cliffortia falcata</i>, <i>Puterlickia pyracantha</i>, <i>Willdenowia striata</i>, <i>Thamnochortus punctatus</i>, <i>Protea repens</i> and <i>Rhus laevigata</i></p> <p>(iii) A population of <i>S. trilophia</i> or an allied taxon occurred on the Paardeberg on granite-derived sandy loam in a community dominated by the tufted restioid <i>Thamnochortus bachmannii</i> (Associates: <i>Willdenowia arescens</i>, <i>W. striata</i>, <i>Restio cuspidatus</i>, <i>R. duRoi</i>, <i>R. monanthus</i>, <i>Leptocarpus vimineus</i>, <i>Cannomois acuminata</i>, <i>Leucospermum calligerum</i>, <i>L. hypophyllocarpodendron</i>, <i>Leucadendron lanigerum</i>, <i>Serruria burmannii</i>, and <i>S. brownii</i>).</p>	<p>sandy slope, Koeberg Hill; virtually pure sand</p> <p>sandy flats adjacent to low dunes bearing broad-leaved scrub (strandveld <i>sensu</i> Taylor, 1978), Blouberg Farm; small proportion of clay in the sand</p>
<i>S. linearis</i>	Scattered plants in a mainly ericeid-restioid (<i>sensu</i> Taylor, 1978) Coastal Fynbos, similar to vegetation associated with <i>S. trilophia</i> , with 65–75 % projective foliage cover	(i) A main 0.6 m stratum of ericeid shrubs and tufted restioids (<i>Phyllica cephalantha</i> and <i>Thamnochortus punctatus</i> co-dominant)	sandy flats, Kalabaskraal

<i>S. furcellata</i>	Scattered plants in a mainly restioid-eroid Coastal Fynbos, 1.0–1.5 m high, similar to the above and to vegetation described for <i>Chondropetalum acockii</i> at this locality by Milewski and Esterhuysen (1977)	(ii) Two populations: similar to the above but with a well-developed proteoid stratum (shrubs of <i>Leucospermum parile</i> to 1.2 m) above the main 0.8 m stratum of ericoid shrubs and tufted restioids	gently undulating sandy base of Dassenberg; virtually pure sand
<i>S. cyanoides</i>	A mainly graminoid (<i>sensu</i> Taylor, 1978) fynbos, resembling Taylor's (1969) <i>Thamnochortus erectus</i> Dune Fynbos Sub-association (Coast Fynbos Alliance; Dune Mixed Fynbos Association), which occurs in the Cape of Good Hope Nature Reserve on 'deep white or grey Fernwood sand' (Taylor, 1969)	A main 0.8 m stratum of ericoid shrubs (e.g. <i>Staavia radiata</i>) and tufted restioids (e.g. <i>Thamnochortus punctatus</i> , <i>Willdenowia sulcata</i>), a ground stratum of creeping shrubs (e.g. <i>Leucospermum hypophyllocarpodendron</i>) and forbs, and very scattered emergent proteoid (e.g. <i>Protea repens</i>) and tall ericoid (e.g. <i>Erica mammosa</i>) shrubs to 1.5 m	patch of sand on flats near Bellville
<i>P. odorata</i>	Scattered to densely grouped plants in ericoid-restioid Coastal Rhenoerbosveld (<i>sensu</i> Taylor, 1978) with 40–60 % projective foliage cover	An open upper stratum of <i>Thamnochortus erectus</i> to 1.3 m and a denser 0.4 m lower stratum of other graminoids, e.g. <i>Hypodiscus willdenowia</i> (physiognomically very prominent) and <i>Scirpus membranaceus</i> , and ericoid shrubs, e.g. <i>Phyllica stipularis</i> ; vegetation adjacent to that in which <i>S. cyanoides</i> grew was marked by the proteoids <i>Leucospermum conocarpodendron</i> (slopes of Table Mountain Sandstone shal- lowly overlain by sand) and <i>Leucadendron confertifolium</i> (relict 'perched' dune of transported, possibly neutral sand)	sandy slopes of Karbonkel-berg
		(i) A main 0.6–0.7 m stratum dominated by the 'heath-like' shrub <i>Elytropappus rhinocerotis</i> , a ground stratum of wiry restioids (e.g. <i>Lepiocarpus rigoratus</i>), succulents (e.g. <i>Lampranthus aduncus</i>), low ericoids (e.g. <i>Diosma hirsuta</i> , <i>Macrostylis villosa</i>) and forbs, and a scattered emergent stratum (to 2.0 m) of the proteoid shrub <i>Leucadendron verticillatum</i>	clay slopes of Joostenberg Hill
<i>P. mucronifolia</i>	Scattered to densely grouped plants in ericoid-restioid Coastal Rhenoerbosveld, with 30–60 % projective foliage cover	(ii) Similar to but lower and denser than the above; a main 0.4–0.5 m stratum was composed predominantly of tufted restioids (e.g. <i>Restio macer</i>), while <i>Leucadendron thymifolium</i> and <i>L. corymbosum</i> formed the emergent stratum	sand-clay flats near Kalabakraal
		(i) A main 0.4–0.5 m stratum of 'heath-like' shrubs (e.g. <i>Rehania ericoides</i> , <i>Elytropappus rhinocerotis</i>) and wiry restioids (e.g. <i>Restio cuspidatus</i>) and a scattered emergent stratum of spindly proteoid shrubs of <i>Leucadendron corymbosum</i> to 2.0 m	clay flats near Bartholomews Klip
		(ii) Similar to but far denser than the above; a main 0.6–0.7 m stratum of low proteoid (e.g. <i>Leucadendron lanigerum</i> , <i>L. stellare</i>) and ericoid shrubs and tufted restioids (e.g. <i>Restio triflorus</i>)	clay flats near Voëlvlei; small proportion of sand in the clay

TABLE 2

Frequency of presence and absence of Restionaceae and Proteaceae associates, in populations of study species of *Serruria*: 1 = *S. trilophia*, 2 = *S. linearis*, 3 = *S. furcellata*, 4 = *S. cyanoides*. Numerator equals the number of populations in which the associate species was recorded within 0.5 m of plants of the study species; denominator equals total number of investigated populations per study species; "+" denotes associate species present in the same stand of vegetation as the study species but not within 0.5 m. See Table 3 for explanation of percentages in parentheses.

Associate species	Study species			
	1 (4 %)	2 (17 %)	3 (0 %)	4 (45 %)
<i>Serruria decipiens</i> R. Br.	1/2	+		
<i>Leucadendron cinereum</i> (Solander ex Ait.) R. Br.	1/2	+		
<i>Protea pulchra</i> Rycroft	1/2	+		
<i>Leucadendron thymifolium</i> (Salisb. ex Knight) Williams	+	+		
<i>Leucadendron lanigerum</i> Buek ex Meisn.	1/2	1/3		
<i>Chondropetalum nudum</i> (Nees) Rottb.	1/2	1/3		
<i>Serruria burmannii</i> R. Br.	1/2	2/3		
<i>Restio monanthus</i> Mast.	2/2	3/3		
<i>Leucospermum parile</i> (Salisb. ex Knight) Sweet		2/3		
<i>Restio form of sieberi</i> Kunth		2/3		
<i>Restio filiformis</i> Poir.		2/3		
<i>Cannomois acuminata</i> (Thunb.) Pillans		3/3		
<i>Leucadendron corymbosum</i> Berg.		+		
<i>Restio bifurcus</i> Nees ex Mast.		1/3	+	
<i>Staberoha cernua</i> (L.f.) Dur. & Schinz		+	+	
<i>Chondropetalum acockii</i> Pillans		+	+	
<i>Hypodiscus aristatus</i> (Thunb.) Nees			+	
<i>Restio quinquefarius</i> Nees			+	
<i>Serruria ciliata</i> R. Br.			+	
<i>Restio paludosus</i> Pillans			+	
<i>Elegia juncea</i> L.				1/1
<i>Thamnochortus erectus</i> (Thunb.) Mast.				1/1
<i>Elegia vaginulata</i> Mast.				1/1
<i>Leucadendron coniferum</i> (L.) Meisn.				1/1
<i>Leucospermum conocarpodendron</i> (L.) Buek ssp. <i>viridum</i> Rourke				1/1
<i>Willdenowia teres</i> Thunb.				+
<i>Leptocarpus vimineus</i> (Rottb.) Pillans	2/2	3/3	+	
<i>Thamnochortus punctatus</i> Pillans	2/2	3/3	1/1	
<i>Staberoha distachya</i> (Rottb.) Kunth	2/2	3/3	1/1	
<i>Leptocarpus impolitus</i> (Kunth) Pillans	2/2	2/3	+	
<i>Thamnochortus obtusus</i> Pillans	2/2	2/3	1/1	
<i>Willdenowia arescens</i> Kunth	2/2	3/3	1/1	
<i>Restio</i> sp. nov. aff. <i>R. tenuissimus</i> Kunth	2/2		+	
<i>Chondropetalum tectorum</i> (L.) Pillans	1/2		+	
<i>Protea repens</i> (L.) L.	1/2		+	
<i>Willdenowia striata</i> Thunb.	2/2	2/3	1/1	
<i>Leucospermum hypophyllocarpodendron</i> (L.) Druce spp. <i>canaliculatum</i> (Buek ex Meisn.) Rourke	2/2	2/3	1/1	
<i>Diastella proteoides</i> (L.) Druce	+		+	
<i>Willdenowia sulcata</i> Mast.	+	3/3	1/1	
<i>Protea acaulos</i> Thunb.	1/2	2/3	+	1/1
<i>Leucadendron salignum</i> Berg.	2/2	1/3	1/1	1/1
<i>Protea scolymocephala</i> Reich.	2/2	2/3	+	1/1
<i>Restio cuspidatus</i> Thunb.	1/2	2/3	+	1/1
<i>Hypodiscus willdenowia</i> (Nees) Mast.	2/2	2/3	1/1	1/1
<i>Thamnochortus fruticosus</i> Berg.	1/2	+		1/1

TABLE 3

Frequency of presence and absence of Restionaceous and Proteaceous associates in populations of study species of *Protea*: 1 = *P. odorata*, 2 = *P. mucronifolia*. Explanation of occurrence values as for Table 2. Percentages in parentheses at top of columns indicate proportion of associates unrecorded for the other study congener.

Associate species	Study species	
	1 (59 %)	2 (27 %)
<i>Thamnochortus bachmannii</i> Mast.	+	
<i>Willdenowia striata</i> Thunb.	+	
<i>Serruria incrassata</i> Buek ex Meisn.	+	
<i>Staberoha cernua</i> (L.f.) Dur & Schinz	+	
<i>Willdenowia arescens</i> Kunth	+	
<i>Leptocarpus vimineus</i> (Rottb.) Pillans	+	
<i>Hypodiscus willdenowia</i> (Nees) Mast.	+	
<i>Elegia squamosa</i> Mast.	2/2	
<i>Thamnochortus fruticosus</i> Berg.	1/2	
<i>Thamnochortus punctatus</i> Pillans	1/2	
<i>Leucadendron thymifolium</i> (Salisb. ex Knight) Williams	1/2	
<i>Leucadendron verticillatum</i> (Thunb.) Meisn.	1/2	
<i>Elegia</i> sp. nov. Esterhuysen 34411	1/2	
<i>Restio</i> sp. nov. Esterhuysen 30849	1/2	
<i>Thamnochortus obtusus</i> Pillans	1/2	
<i>Serruria brownii</i> Meisn.	1/2	
<i>Elegia vaginulata</i> Mast.	1/2	
<i>Restio</i> sp. nov. Esterhuysen 32525	1/2	
<i>Leucadendron cinereum</i> (Solander ex Ait.) R. Br.	1/2	
<i>Protea scolymocephala</i> Reich.	1/2	
<i>Restio duthieae</i> Pillans	2/2	+
<i>Restio macer</i> Kunth	1/2	+
<i>Hypodiscus paludosus</i> Pillans	2/2	1/2
<i>Chondropetalum rectum</i> (Mast.) Pillans	2/2	1/2
<i>Leucadendron lanigerum</i> Buek ex Meisn.	1/2	1/2
<i>Leptocarpus rigoratus</i> Mast.	2/2	2/2
<i>Restio cuspidatus</i> Thunb.	2/2	2/2
<i>Elegia parviflora</i> Kunth	2/2	2/2
<i>Leucadendron corymbosum</i> Berg.	1/2	2/2
<i>Restio triflorus</i> Rottb.	+	1/2
<i>Restio</i> sp. nov. Esterhuysen 30859		1/2
<i>Leucadendron stellare</i> (Sims) Sweet		2/2
<i>Thamnochortus sporadicus</i> Pillans	(+)	2/2
<i>Serruria candicans</i> R. Br.		+

FURTHER NOTES ON *PROTEA* IN SOUTH AFRICA

J. P. ROURKE

(Compton Herbarium, Kirstenbosch)

ABSTRACT

Three new species, *Protea nubigena* Rourke, *P. piscina* Rourke and *P. inopina* Rourke, as well as two new subspecies, *P. longiflora* Lam. ssp. *potbergensis* Rourke and *P. roupelliae* Meisn. ssp. *hamiltonii* Beard ex Rourke, are described.

UITTREKSEL

AANVULLENDE NOTAS OOR *PROTEA* IN SUID-AFRIKA

Drie nuwe spesies, *Protea nubigena* Rourke, *P. piscina* Rourke en *P. inopina* Rourke asook twee subspesies, *P. longiflora* Lam. ssp. *potbergensis* Rourke en *P. roupelliae* Meisn. ssp. *hamiltonii* Beard ex Rourke, word beskryf.

In concluding the groundwork towards completing a revision of *Protea* in South Africa, it has been found necessary to describe certain additional taxa. This is the final contribution in a series of miscellaneous notes published preparatory to the appearance of a revision of the South African species of *Protea*.

***Protea nubigena* Rourke, sp. nov.;** a habitu brevi ramosissimo, inflorescentiis parvulis, stylis 35–40 mm longis, foliis oblanceolatis vel ellipticis glabris glaucescentibus 40–60 mm longis 7–14 mm latis, distinguitur. Crescit scopuli graminei verticales ad 2 300 m supra mare in Dracomontes.

Fruticulus ramosissimus, 0,5–0,7 m altus, caulibus a caudice exorientes. *Caules* ramosissimi, 2–5 mm in diam., nudi, sed foliis aggregatis apices versus; rami cicatricibus foliorum delapsorum notati. *Folia* ascendentia, oblanceolata vel elliptica, 40–60 mm longa, 7–13 mm lata, glauca, glabra; apices obtusi. *Inflorescentia* globosa, 40–50 mm in diam. *Receptaculum* conicum, acutum, 10 mm latum, 10–12 mm altum. *Bractee involucrales* 3–4 seriatae, eburneae vel roseae soridae, glabrae; series intima oblonga—linearia, 25–30 mm longa, 3–7 mm lata, apices rotundatos concavos; series externa lata ovata 10–15 mm longa, 10 mm lata, margines brunescetes. *Perianthium* 30–35 mm longum; tubus glaber extus sed marginibus interioribus distalibus setosis; unguis et limbi setosi sparsi, indumento fulvo. *Stylus* 35–40 mm longus, arcuatus adaxialis, albus. *Stigma* peranguste linearie, 10 mm longum roseum.

An erect, much branched shrublet 0,5–0,7 m in height, to 0,5 m in diam., with numerous 10–15 mm diam. stems arising from a subterranean caudex, very

Accepted for publication 1st June, 1978.

occasionally with a short single main stem to 20 mm in diam., swollen at base to form a bulbous caudex. *Stems* highly branched, woody, 2–5 mm in diam., with short (20–50 mm) growth increments; glabrous, covered with dark verrucose bark; leaf scars prominent; bare of leaves except for ultimate and penultimate growth increments. *Leaves* erect, ascending, oblanceolate—elliptic, glaucous, glabrous, 40–60 mm long, 7–13 mm wide; apices obtuse, margins distinct. *Inflorescence* globose, 40–50 mm in diam., surrounded by several axillary shoots. *Receptacle* conic, acute, 10 mm wide 10–12 mm in height. *Involucral bracts* 3–4 seriate, greenish cream to dirty pink, glabrous; inner series linear-oblong 25–30 mm long, 3–7 mm wide, apices rounded, slightly concave; outer series broadly ovate 10–15 mm long, 10 mm wide, margins brown. *Perianth* 30–35 mm long, slightly adaxially curved; tube region 10 mm long, glabrous externally but inner margins densely setose distally; claws sparsely setose with a ferruginous indumentum on inner and outer surface; limbs 10 mm long, apices sharply acuminate, outer surface sparsely setose with a tawny ferruginous indumentum. *Anthers* 4, subsessile, 5–6 mm long, filaments 1.5 mm long. *Style* 35–40 mm long, adaxially curved, tapering subterminally, white. *Pollen presenter* very narrowly linear, simple, scarcely differentiated from style, 10 mm long, pink. *Ovary* obconic 5–6 mm long, covered with long, straight, tawny trichomes. *Hypogynous scales* lanceolate, acuminate, 1–5 mm long.

Type: Royal Natal National Park above Policeman's Helmet Ridge on vertical cliffs of south-east aspect, facing Tugela Gorge, on the ridge leading to The Witches, 2 300 m (7 600 ft), 4/4/1978, J. P. Rourke 1635 (NBG, holo.!; PRE, NU, J, BOL, K, MO, S and in herb. Royal Natal National Park Mont-aux-Sources, iso.).

Protea nubigena may be distinguished from all other *Protea* species of the summer rainfall region of South Africa, on account of its dwarf, highly branched growth habit, the very small inflorescences and flowers (styles 35–40 mm long), and the small, oblanceolate, glabrous, glaucescent leaves 40–60 mm long, 7–14 mm wide.

A most remarkable species presently known from a single locality in the Natal Drakensberg within the Royal Natal National Park where it grows on vertical cliffs and ledges at an elevation of 2 300 m (7 600 ft), on Basalt lavas of the Stormberg series. The associated vegetation consists of coarse turf composed of *Heteropogon contortus* and *Themeda triandra* with *Buchenroedera lotononoides*, *Cliffortia browniana*, *Helichrysum sutherlandii* and *Talbotia elegans* being the other predominant species on the ledges.

SPECIMENS EXAMINED:

NATAL—2828 (Bethlehem): Natal National Park, Policeman's Helmet Ridge, on cliff, south aspect (-DB), 8 000 ft., 18/7/1964, Esterhuysen 30249 (BOL); Royal Natal National Park, Policeman's Helmet Ridge, Oct. 1976, J. Scotcher s.n.

(NBG 110, 236); Royal Natal National Park, above Policeman's Helmet Ridge on vertical cliffs of south-east aspect facing Tugela Gorge, on the ridge leading to The Witches, 7 600 ft., 4/4/1978, *Rourke 1635* (NBG, PRE, NU, J, BOL, K, MO, S).

Protea piscina Rourke, sp. nov.; fruticulus nanus caespitosus; foliis scabris, acicularibus—canaliculatis vel linearibus, 15–30 cm longis, 2–5 mm latis, bracteis luteis vel subroseis indumento albo sericeo, distinguitur.

Fruticulus nanus caespitosus, 1 m in diam., 300 mm altus. *Caules* ramosissimi, subterranei, 3–8 mm in diam., glabri, folia in caespites terminales gerentes. *Folia* acicularia—canaliculata vel linearia—plana, 150–300 mm longa, 2–5 mm lata, scabra, pubescentia dum immatura sed mox glabra; apices cuspidati. *Inflorescentiae* obconicae—turbinatae, 35–50 mm longae, 40–50 mm in diam. *Receptaculum* late conicum, depressum, 5–15 mm latum, 5–10 mm altum. *Bracteeae involucales* 4–5 seriatæ, luteae vel subroseae, indumentum sericeum, album; series externa ovata acuta, 5–7 mm lata, 7–10 mm longa; series intima, oblonga—linearia, 20–35 mm longa, 2–5 mm lata, apices rotundatos concavos. *Perianthium* 30–35 mm longum; tubus glaber, quadrangulatus, 8–10 mm longus; Ungues dense lanati; limbi lineares acuminati, lanati. *Stylus* 30–35 mm longus, arcuatus adaxialis. *Stigma* peranguste lineare, 5–7 mm longum.

Dwarf, tufted shrublet, forming clumps or mats to 1 m in diam., 300 mm in height. *Stems* subterranean, highly divaricate, 3–8 mm in diam., glabrous, producing terminal tufts of leaves at ground level; new shoots regenerate from subterranean stems after burning. *Leaves* acicular—canaliculate to linear and flat, 150–300 mm long, 2–5 mm wide; scabrous, margins horny, apices sharply cuspidate to uncinat; pubescent when young, soon glabrous but occasionally with some pubescence remaining, particularly in the petiolar region. *Inflorescences* obconic, turbinate, 35–50 mm long, 40–50 mm in diam. *Involucral receptacle* broadly conic, depressed, 5–15 mm wide, 5–10 mm high. *Involucral bracts* 4–5 seriate, pale yellow, occasionally flushed with pink; outer series ovate acute, 5–7 mm wide, 7–10 mm long, margins ciliate; inner series oblong—linear, 20–35 mm long, 2–5 mm wide, apices concave, rounded; covered with a soft, white, sparsely sericeous indumentum. *Perianth* 30–35 mm long, straight to slightly adaxially arcuate; tube region glabrous, quadrangular, winged, 8–10 mm long, inner surface slightly pubescent distally; claws slender, densely lanate with a shaggy white indumentum, occasionally interspersed with tawny trichomes; limbs 10 mm long, linear, markedly acuminate, with a white lanate indumentum. *Style* slightly adaxially arcuate, tapering terminally, 30–35 mm long, occasionally puberulous proximally. *Pollen presenter* simple, linear, acute, scarcely differentiated from style, 5–7 mm long. *Ovary* 3–5 mm long, obconic, covered with long, straight tawny trichomes. *Hypogynous scales* lanceolate acute, 2 mm long.

Type: Upper Olifants River Valley, between Visgat and Bollemakiesiekloof, Dec., *Rourke 1506* (NBG, holotype; BOL, PRE, K, MO, S, M, isotypes).

Although clearly allied to *P. scabra* R. Br., which is characterised by the presence of a rusty brown indumentum on the involucre bracts, *P. piscina* is distinguished by the pale yellow (very rarely pink-flushed) involucre bracts covered with a soft white, sericeous, indumentum, and the acicular—canalicate to linear leaves, 150–300 mm long, 2–5 mm wide. At no point do the areas of distribution of the two species overlap. *P. piscina* is distributed to the north and east of the range of *P. scabra*; from the Cedarberg to the Cold Bokkeveld and Piketberg and with the extreme easterly populations occurring from Swellendam along the southern foothills of the Langeberg, to Platteklouf.

SPECIMENS EXAMINED

CAPE PROVINCE—3218 (Clanwilliam): Piketberg, top of Versveld's Pass (-DC), March, *Paterson-Jones s.n.* (NBG 93932); Piketberg mountain, southeast of town, Dec., *H. C. Taylor 4479* (NBG, STE); Piketberg mountain (-DD), Feb., *van der Westhuizen s.n.* (BOL); Kafferskloof Farm Jan., *Summers s.n.* (NBG 85502).

—3219 (Wuppertal): Grootberg, Clanwilliam, southwest slopes (-AC), Dec., *Esterhuysen 4191* (BOL); top of Olifants river mountains, behind Warmbaths (-CA), Sept., *Stephens 6910* (BOL); Skoongesig, (-CC), Nov., *Hanekom 530* (PRE); Grootfontein, Olifantsriver valley, Sept., *Oliver 3986* (STE); hills a mile southeast of Keerom, Nov., *Pillans 8775* (BOL).

—3319 (Worcester): Plateau of Skurfdeberg between Olifants and Kromme river (-AA), Dec., *Andreae 197* (PRE, STE); road between Rosendalfontein and Visgat, Nov., *Pillans 9642* (BOL); Olifants river valley, Onderboskloof, Jan., *Esterhuysen 14296* (BOL); Upper Olifants river valley between Visgat and Bollemakiesiekloof, Dec., *Rourke 1506* (NBG, BOL, PRE, K, MO, S, M); top of Gydo Pass (-AB), July, *Markötter s.n.* (STE 19382); Witzenberg, top and eastern slopes (-AC), Dec., *Andreae 155* (PRE).

—3420 (Bredasdorp): Swellendam (-AB), June, *Harold Fry s.n. 4985* in herb. Galpin (BOL, SAM, PRE); hill close to Swellendam just north of town, Oct., *Marloth 7957* (PRE); Langeberg, near Swellendam, Sept., *Muir 2752 & 2753* (PRE); hill southeast of Swellendam on road to Bontebok Park, Nov., *Williams 1727* (NBG); below the Crown mountain, Swellendam, Aug., *Wurts 270* (NBG); hills at Voormansbosch (-BA), Sept., *Zeyher 3671* (SAM); In lat. mont. pr. Swellendam, *Niven s.n.* (K); Bontebok Park, Feb., *Grobler 601* (STE).

—3320 (Montagu): Buffelsjagtsrivier at Sparrbosch (-DC), 30/7/1831, *Drège 3364* (P).

—3321 (Ladismith): Platteklouf, near Riversdale (-CC), Oct., *Dekenah s.n.* (NBG 95694).

Protea inopina Rourke, sp. nov.; a *P. arborea* Houtt., bracteis dense ferrugineis velutinis et habitu humilis, caulibus simplicibus (raro ramosis) ad 1 m altis caudice exorienti, distinguendus.

Frutex humilis, ad 1 m altus. *Caules* simplices (raro ramosi), 10–12 mm in diam., glabri, caudice exorienti. *Folia* elliptica vel late oblanceolata 120–180 mm longa, 25–50 mm lata, glabra, glauca, cartilaginea vel coriacea. *Bractea* 5–7 seriatæ, dense velutinæ ferruginiæ, præter seriem intimam partialem pubescentiæ. *Perianthium* 80–90 mm longum; tubus glaber, 10 mm longus, porcatus; ungues tenues, glabri; limbi 30 mm longi, crassi, tomentosi vel lanati. *Stylus* 80–90 mm longus, leviter arcuatus. *Stigma* 15–20 mm longum, tenue. *Ovarium* obovoideum, 3–5 mm longum, trichomatibus fulvis vestitis.

Low, multiple-stemmed shrub 0.5 to 1 m in height, the stems arising from a woody subterranean rootstock. *Stems* erect, glabrous, 10–12 mm in diam., simple to occasionally branched, more usually simple. *Leaves* elliptic to broadly oblanceolate, 120–180 mm long, 25–50 mm wide, glabrous, glaucous, cartilaginous to coriaceous in texture, sessile, but frequently twisted in petiolar region. *Inflorescence* globose to spherical in bud, becoming elongate before anthesis with the perianths projecting 30–50 mm beyond the involucre bracts prior to anthesis, becoming ovoid when fully open, 100–120 mm in diam.; substipitate to stipitate, stipe to 30 mm long. *Involucral receptacle* prominent, conic-acute, 40–45 mm wide, 20–30 mm high. *Involucral bracts* 5–7 seriate, covered with a densely velutinous, ferruginous indumentum in bud stage; outer series ovate acute, tightly imbricate, 10–15 mm wide, 10–20 mm long, covered with a densely velutinous ferruginous indumentum; inner series broadly ovate to ovate—oblong, obtuse, 15–25 mm wide, 20–25 mm long, with a ferruginous indumentum towards apex and midrib, otherwise glabrescent, pale green. *Perianth* 80–90 mm long, tube 10 mm long, prominently ridged, glabrous but minutely puberulous along inner margin of tube lip; claws slender, glabrous; limbs stout, 30 mm long with a densely tomentose to lanate white indumentum, except on the adaxial limb, apices incurved very acuminate, densely lanate. *Anthers* 4, linear, subsessile, 20 mm long, apical boss green, sagittate. *Style* 80–90 mm long, adaxially arcuate, glabrous, tapering terminally. *Pollen presenter* 15–20 mm long, slender, linear, not clearly differentiated from style. *Ovary* obovoid, 3–5 mm long covered with a small tuft of straight tawny trichomes. *Hypogynous scales* 1.5 mm long, narrowly and obliquely ovate. *Fruits* large, ovoid 10–12 mm long 6–7 mm wide, nut-like.

Type: Bergvlei mountains, east of Paleisheuvel, between Bergvlei-se-Berg and Pretoriuskrans, above the farm Mieliedraai, 27/9/1977, J. P. Rourke 1619 (NBG, holo.!, PRE, STE, BOL, MO, K, S, L, iso.!).

P. inopina is distinguished by the densely ferruginous, velutinous pubescence on the involucral bracts (particularly in the bud stages) and by the dwarf growth habit with simple (only very rarely branched) stems up to 1 m in height arising from a persistent rootstock. Another significant diagnostic feature of this species is the inordinately large size of the fruits. Ovoid in form, 10–12 mm long and 6–8

mm in diameter they are three times the size of the fruits in *P. arborea*. Together with those of *P. magnifica*, they are the largest fruits recorded in *Protea*.

SPECIMENS EXAMINED

CAPE—3218 (Clanwilliam): Bergvlei Mountains, east of Paleisheuvel, between Bergvlei-Se-Berg and Pretoriuskrans, above the farm Mieliedraai (-DB), 27/9/1977, *Rourke 1619* (NBG, PRE, STE, K, BOL, MO, S, L); on the farm Wilgerbosdrif, Olifants Rivier Mountains, about 13 miles northwest of Piekenierskloof Pass, *M. Schonken s.n.* (STE 30939); Citrusdal area, 10/11/1966, *M. Vogts s.n.* (NBG 85255).

***Protea longiflora* Lam. ssp. *potbergensis* Rourke, ssp. nov.**

Frutex vel arbor parva, ad 4 m alta. *Folia* ovata vel late ovata, basibus cordatis; velutina, postea glabrescentia; 60–90 mm longa, 45–65 mm lata, sed decrescentia (35 mm longa, 25 mm lata), ad apicem caulis. *Stylus* 110–130 mm longus.

Shrub or small tree to 4 m. *Leaves* ovate to broadly ovate, cordate at base, velutinous at first becoming glabrous about a year later, margins thickly ciliate; lower leaves 60–90 mm long, 45–65 mm wide, decreasing in size towards shoot apex to 35 mm long and 25 mm wide. *Style* 110–130 mm long.

Type: Potberg, south slopes near Hamerkop, flowering in hort. J. P. Rourke 25/5/1976, *Rourke 273* (NBG, holo.; PRE, BOL, K, MO, S, iso.)

Apparently confined to the Potberg and adjacent coastal flats, this subspecies is distinguished by its large, ovate to broadly ovate leaves, velutinous initially with thickly ciliate margins.

SPECIMENS EXAMINED

CAPE—3420 (Bredasdorp): Potberg, south slopes near Hamerkop (-BC), fld. in hort. J. P. Rourke 25/5/1976, *Rourke 273* (NBG, PRE, BOL, K, MO, S); Mr Michlers farm, south end of Potberg, Dec. (in fruit), *Williams 629* (NBG); Middle south slope of the Potberg, margin of a stream, Oct. 1940, *Pillans 9382* (BOL).

***Protea roupelliae* Meisn. ssp. *hamiltonii* Beard ex Rourke, ssp. nov.; a habitu nano prostrato, distinguitur.**

Fruticulus procumbens, maxime divaricatus ad 300 mm altus, teges caespitosa ad 1 m in diam. formans; caule principali singulari. *Rami* crassi, horizontaliter effusi. *Inflorescentia* et flos characteres ut in sub-speciem typicam.

Low, procumbent, highly divaricate shrublet to 300 mm in height, forming a tufted mat to 1 m in diam.; with a single main stem. *Branches* stout, short, sprawling horizontally along ground. *Inflorescence* and floral characters as in typical subspecies.

Type: Wartberg, Nelshoogte Forest Reserve, 30/1/1975, Rourke 1467 (NBG, holo.; PRE, K, MO, iso.).

This extraordinary local race of *P. roupelliae* was discovered by Dr P. D. Hamilton of Barberton early in 1957. He showed the populations to Dr J. S. Beard who proposed that it be named *P. roupelliae* var. *hamiltonii*, although no formal description was ever published. It appears that Beard referred to this local race as *P. roupelliae* var. *hamiltonii* in correspondence with the Botanical Research Institute, Pretoria, but he did not affix a manuscript name to any herbarium specimens. Moreover, for several years plants have been offered for sale by a well-known firm of *Protea* growers in Cape Town under this *nomen nudum*. Beard's proposed epithet is here adopted and validated although it is considered that subspecific rank is more appropriate for this dwarf race of *P. roupelliae* on account of its morphological and geographical distinctness.

SPECIMENS EXAMINED

TRANSVAAL—2530 (Lydenburg): Nelshoogte Plateau (-DD), Dec., *P. D. Hamilton* s.n. No. 1525 in herb. Beard (NU); Nelshoogte Plateau, Aug., *P. D. Hamilton* s.n. No. 1024 in herb. Beard (NU); Nelshoogte, a small creeping plant, *P. D. Hamilton* s.n. No. 985a, in herb. Beard (NU); Nelshoogte Plateau, March, J. S. Beard 880 (NU); Dr. Hamilton Nature Reserve, Nelshoogte (-DB), Dec., Muller 2127 (PRE); Dr Hamilton Protea Reserve, Jambila Forest Reserve, Nov., Edwards 4127 (PRE); Wartberg, Nelshoogte Forest Reserve, Jan., Rourke 1467 (NBG, PRE, K, MO).

ACKNOWLEDGEMENTS

I am very much indebted to the Director of the Natal Parks, Game and Fish Preservation Board for generously placing the full facilities of his organisation at my disposal to facilitate the collection of *P. nubigena*. In particular, I am deeply grateful to a member of his staff, Mr John Scotcher, whose sustained interest over several years led to the rediscovery of this species' natural habitat and without whose planning and organisation the mission would not have been the success it was. Finally, were it not for the sturdy assistance of Mr R. E. Levitt and Mr J. Scotcher, who supported the author on a rope while the type material was being collected, an adequate account of *P. nubigena* would not have been possible.

FLAVONOIDS OF THE SUMMER RAINFALL PROTEAS AND THEIR CHEMOTAXONOMIC SIGNIFICANCE

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ABSTRACT

Flavonoids were surveyed (by paper chromatography) in leaves of 15 summer rainfall *Protea* species. Five different 3-O-glycosides of quercetin were found, viz. the arabinoside, galactoside, glucoside, rhamnoside and rutinoside. Most species contained only 3 different glycosides but one species, *P. laetans* L. E. Davidson, contained all five. *P. laetans*, also, was the only species to contain leucoanthocyanins. All species, except three contained abutin and none contained cyanogenic compounds.

UITTREKSEL

FLAVONOÏEDE VAN DIE SOMERREËNSTREEK PROTEAS EN HULLE CHEMIES-TAKSONOMIESE BETEKENIS

'n Papierchromatografiese opname is gedoen van die voorkoms van flavonoïede in die blare van 15 *Protea* spesies van die somerreënstreek. Vyf verskillende 3-O-glikosiede van kwersetien is gevind, nl. die arabinosied, galaktosied, glukosied, rhamnosied, en rutinosied. Meeste spesies het slegs drie van die glikosiede bevat. *P. laetans* daarenteen al vyf. *P. laetans* was ook die enigste spesies wat leukoantosianiene bevat het. Al die spesies behalwe drie het arbutien bevat, maar geen sianogeniese stowwe nie.

INTRODUCTION

Comparatively little is known about the phytochemistry of indigenous South African plants. A study of the summer rainfall proteas was therefore carried out to determine their flavonoid glycoside content. This would be of value for several reasons. Mainly, it would serve to determine the chemical relationships between the various species in this group and also variations within species. A survey of flavonoids and other phenolic compounds has not yet been carried out and it would be worthwhile to screen for novel compounds.

Another reason for a chemical survey of these plants is the position of *Protea laetans*. This species was recently described by Davidson (1975) and it was desirable to examine its flavonoid content and compare this with related taxa. Also, *P. caffra*, *P. multibracteata*, and *P. rhodantha* all have very similar morphology and it would be of interest to know whether this similarity carried through to their flavonoid content.

Accepted for publication 19th May, 1978.

Flavonoids were chosen as the compounds of interest in this study because of their many desirable properties as summarised by Harborne (1967). Elsworth and Martin (1971) reported the possible presence of quercetin in four species reported here and also the possibility that kaempferol could be present in trace amounts. Since their work was done on acid-hydrolysed plant extracts it was decided to expand on this and attempt to isolate and identify all the unhydrolysed flavonoid glycosides for this study.

In another study, members of the Proteaceae were found to contain both hydroquinone and its glucosylated derivative arbutin. These compounds were reported to be present in all of the 29 species studied (van Oudtshoorn, 1963). To extend this survey, all plants in the present study were examined for the presence of arbutin. Recent work in this laboratory has established the presence of acylated forms of arbutin in several *Protea* spp. (Perold and Rosenberg).

METHODS

The plant material was collected from a variety of locations in South Africa and air dried. Voucher specimens are deposited in the Moss Herbarium, University of the Witwatersrand. The dried leaves were milled and extracted with 80% methanol. After concentration, the extract was applied to Whatman 3 MM paper; the flavonoids were separated and purified using n-butanol:acetic acid:water (4:1:5) (BAW), 15% acetic acid, and n-butanol:ethanol:water (4:1:2,2) (BEW) (Harborne, 1967). The flavonoid glycosides were compared with authentic samples by R_f values (Table 1) in BAW, phenol:water (500:125) (PhOH), 15% HOAc and water. The u v spectra of all five glycosides were similar, Band I absorbing at 258 nm and Band II absorbing at 362 nm in 80% methanol.

For comparison purposes two-dimensional paper chromatograms were run on Whatman No. 1 paper, using BAW and 15% HOAc. When viewed under uv light it was difficult to locate all the dark absorbing flavonoids amongst the blue fluorescent compounds. This was overcome by placing a fluorescent sheet of paper under the chromatogram which blended with the blue spots thus clearly showing the dark flavonoids.

All samples of plant material were examined for hydrogen cyanide-producing compounds in the following manner. A small sample of each aqueous plant extract was hydrolysed with β -glucosidase which was obtained commercially from sweet almond meat. The released HCN was detected by picric acid papers suspended over the solution in an enclosed round bottom flask. All positive tests were checked by the Dilute Hydrochloric Acid Test (Vogel, 1942).

The presence of leucoanthocyanins was determined by hydrolysing the plant extracts with 2N HCl in a test tube and then extracting with amyl alcohol. Delphinidin and cyanidin were identified by comparison with authentic standards in respect to R_f values on paper chromatograms and u v maxima (Harborne, 1973).

Unhydrolysed, methanolic plant extracts were used for the survey of arbutin and hydroquinone. Spots of these extracts were applied to Whatman No. 1 paper chromatograms which were developed overnight in BAW or BPW (n-butanol:pyridine:water-6:4:3). After air drying, the chromatograms were sprayed with Pauly's Reagent (0.5% solution of diazotised sulfanilic acid in 10% aqueous Na_2CO_3). The arbutin and hydroquinone appeared as red spots on a white or pale cream background.

TABLE 1.
 R_f Values of Phenolic Glycosides of Summer Rainfall Protea Species.

Compound	R_f values (x100) in			
	BAW	PhOH	15% HOAc	H ₂ O
Quercetin 3-arabinoside	70	61	33	07
Quercetin 3-galactoside	62	62	48	12
Quercetin 3-glucoside	58	62	35	06
Quercetin 3-rhamnoside	77	56	55	22
Quercetin 3-rutinoside	49	46	58	27
Arbutin	48	BPW 65		
Hydroquinone	84	87		

RESULTS AND DISCUSSION

The flavonoids in the leaves of twenty-six different samples of fifteen species of *Protea* are reported in Table 2. Along with the chemical results are also shown the geographical location from which the plant sample was collected. All plants contained only the one aglycone, quercetin, and any variations arose from the different 3-O-glycosides present. Flavonols are the flavonoids generally associated with the more primitive woody members of the Dicotyledoneae. The presence of the flavonol quercetin in this group of proteas suggests that it is rather primitive. Also, since it is the only aglycone present and has a simple glycosylation pattern, all members of this group are probably of a similar evolutionary age.

Quercetin has been reported previously in four of the species studied here (Elsworth & Martin, 1971; van Oudtshoorn, 1963). The presence of kaempferol was reported in two of these species but in this study no kaempferol could be found. The plants showed four different patterns of quercetin glycoside distribu-

tion. The galactoside, glucoside and rhamnoside were distributed throughout while the arabinoside and rutoside were restricted in their distribution.

P. multibracteata and *P. rhodantha* showed chemical variation within the species while all other species had only one pattern of flavonoids. Four samples of *multibracteata* contained three of the quercetin glycosides while one sample contained an extra glycoside. *P. rhodantha* exhibited three different glycoside patterns. As can be seen from Table 2 *P. multibracteata* and *P. rhodantha* are the only two species examined which show the property of chemical variation.

It is probable that the rutin (quercetin-3-O-rhamnogalactoside) found in these plants is biosynthesized from quercetin-3-O-glucoside by the addition of rhamnose. This sequence of building up diglycosides of flavonoids from the monoglycosides has been suggested by Harborne (1975).

All plants in this study were tested for cyanogenesis and found negative. Hegnauer (1969) reported that *P. cynaroides* L., one of the winter rainfall *Protea* species, gave a positive test for HCN. This is the only member of the sub-family Proteoideae which was reported positive. (All the South African Proteaceae except for one genus, *Brabeium*, belong to this sub-family.) The present study yielded contrary results, for when material of *P. cynaroides* was collected from three different sources, it was found negative in all cases. On the other hand, ten of thirty-seven species of *Leucadendron* and *Leucospermum* tested for cyanogenesis gave positive results (Glennie).

The only species which contained leucoanthocyanins was *P. laetans*. The anthocyanins released on acid hydrolysis of the plant material were identified as cyanidin and delphinidin. In addition to being the only species to contain leucoanthocyanins, *P. laetans* is the only species to contain all five quercetin glycosides. These two properties appear to be unique to *P. laetans* and delimit this new species from the others.

All plant samples of summer rainfall proteas, with the exception of *P. rubropilosa*, *P. nubigena* and *P. comptonii*, contained arbutin and many contained its aglycone hydroquinone. It is probable that the hydroquinone came from the breakdown of arbutin during the collecting and drying of the plant material. For this reason the distribution pattern of hydroquinone is not considered, as it could be of dubious value. Including this study, arbutin has now been reported present in 41 species of 6 genera in the Proteoideae. Outside this sub-family and the Ericaceae, where it is widespread, its occurrence is rare and erratic, being found mainly in *Malus* and *Pyrus* spp.

Arbutin was found to be absent from *P. comptonii* and *P. rubropilosa* and to be replaced by several esters of 2-hydroxy-4-hydroxymethylphenylalloside. Both 6-O-cinnamate and 6-O-benzoate of 2-hydroxy-4-hydroxymethylphenyl β -D-allopyranoside were found in these two species (Perold, Beylis and Howard, 1973b). The newly described species, *P. nubigena*, also does not contain arbutin but neither does it contain the same replacement compounds as *P. rubropilosa*.

TABLE 2

Distribution of Phenol Glycosides in Summer Rainfall *Protea* Species, by paper chromatographic analysis.

Species	Compound						Geographical Source
	1	2	3	4	5	6	
<i>P. caffra</i> Meissner		+	+	+		+	Magaliesburg
<i>P. comptonii</i> Beard		+	+	+			Haenertsburg
<i>P. curvata</i> N.E.Br.		+	+	+	+	+	Barberton
<i>P. dracomontana</i> Beard		+	+	+		+	Drakensberg
<i>P. gagedi</i> J. F. Gmelin		+	+	+		+	Barberton (2 samples)
<i>P. laetans</i> L. E. Davidson	+	+	+	+	+	+	Blyde River (2 samples)
<i>P. multibracteata</i> Phillips		+	+	+		+	Oribi, S. Coast Natal
<i>P. multibracteata</i> Phillips		+	+	+		+	Port St Johns (2 samples)
<i>P. multibracteata</i> Phillips		+	+	+		+	Kokstad
<i>P. multibracteata</i> Phillips	+	+	+	+		+	S. Coast Natal
<i>P. nubigena</i> Rourke		+	+	+			Tugela Gorge
<i>P. parvula</i> Beard		+	+	+	+	+	Dullstroom
<i>P. rhodantha</i> Hook f.		+	+	+		+	Nels Hoogte
<i>P. rhodantha</i> Hook f.		+	+	+		+	Blyde River
<i>P. rhodantha</i> Hook f.		+	+	+		+	Long Tom Pass
<i>P. rhodantha</i> Hook f.		+	+	+		+	Iron Crown
<i>P. rhodantha</i> Hook f.	+	+	+	+		+	Iron Crown
<i>P. rhodantha</i> Hook f.		+	+	+	+	+	Blyde River
<i>P. rhodantha</i> Hook f.		+	+	+	+	+	Haenertsburg
<i>P. rhodantha</i> Hook f.		+	+	+	+	+	Sheba (2 samples)
<i>P. rubropilosa</i> Beard		+	+	+			Blyde River
<i>P. roupelliae</i> (dwarf form) Meissner		+	+	+		+	Barberton
<i>P. simplex</i> Phillips		+	+	+		+	S. Coast Natal
<i>P. transvalensis</i> Phillips		+	+	+		+	Haenertsburg
<i>P. transvalensis</i> Phillips		+	+	+		+	Iron Crown
<i>P. welwitschii</i> Engel		+	+	+	+	+	Johannesburg

Key 1 - Quercetin-3-0-arabinoside, 2 - Quercetin-3-0-galactoside,
 3 - Quercetin-3-0-glucoside, 4 - Quercetin-3-0-rhamnoside,
 5 - Quercetin-3-0-rutinoside, 6 - Arbutin.

and *P. comptonii*. In *P. nubigena* arbutin appears to be replaced by several phenolic compounds which are yet to be identified.

It is of interest that *P. comptonii* and *P. rubropilosa* lack arbutin and that both contain the replacement glycosides, rubropilosin and pilorubrosin. They also contain the same complement of flavonoids, viz. the galactoside, glucoside and rhamnoside of quercetin. These species have similar morphology which tends to distinguish them from related taxa and one of the features separating them from each other is their geophysical distribution.

P. comptonii is found in a small area south of Barberton, Transvaal, while *P. rubropilosa* is found on the escarpment of the north-eastern Transvaal. Previously, the 6-0-benzoate of 2 hydroxy-4-hydroxymethylphenyl—D-glucopyranoside had been isolated from the winter rainfall *Protea lacticolor* Salisb. (Perold, Beylis and

Howard, 1973a). It appears that this ester also replaces arbutin in *P. laticolor* as no arbutin or hydroquinone could be detected.

Two different samples of *P. gaguedi* were collected and examined. Both of the plants examined have similar morphology and inhabit the same ecological zone. The main difference between these samples is their time of blooming; one blooms in August while the other blooms in October. This time of flowering appears to be the only difference as both plants exhibited identical flavonoid and arbutin content as well as cyanogenic properties.

ACKNOWLEDGEMENT

Professor G. W. Perold (Department of Chemistry) is thanked for his encouragement and for his support of this work. Dr. J. P. Rourke (National Botanic Gardens of South Africa, Kirstenbosch) is thanked for supplying a sample of *Protea nubigena*.

REFERENCES

- DAVIDSON, L. E., 1975. A New species of *Protea* in the Transvaal. *Jl S. Afr. Bot.* **41**: 207–210.
- ELSWORTH, J. F. and MARTIN, K. R., 1971. Flavonoids of the Proteaceae, Part 1. A Chemical Contribution to Studies on the Evolutionary Relationships in the S. African Proteoideae. *Jl S. Afr. Bot.* **37**: 199–212.
- GLENNIE, C. W. Unpublished results.
- HARBORNE, J. B., 1967. *Comparative Biochemistry of the Flavonoids*. London and New York: Academic Press.
- HARBORNE, J. B., 1973. *Phytochemical Methods*. London: Chapman and Hall.
- HARBORNE, J. B., 1975. Flavone and Flavonol Glycosides. In: Harborne, J. B., Mabry, T. J. and Mabry, Helga (eds.), *The Flavonoids*. London: Chapman and Hall.
- HEGNAUER, R., 1969. *Chemotaxonomie der Pflanzen*. Volume 5. Basel and Stuttgart: Birkhauser.
- PEROLD, G. W., BEYLIS, P. and HOWARD, A. S., 1973a. *J. chem. Soc. Perkin I*: 1973, 638–643.
- PEROLD, G. W., BEYLIS, P. and HOWARD, A. S., 1973b. *J. chem. Soc. Perkin I*: 1973, 643–649.
- PEROLD, G. W. and ROSENBERG, M. E. K. Unpublished results.
- VAN RHEEDE VAN OUDTSHOORN, M. C. B., 1963. Distribution of phenolic compounds in some South African Proteaceae. *Planta med.* **11**: 399–406.
- VOGEL, A. I., 1942. *Qualitative Chemical Analysis*. London: Longmans, Green.

CHROMOSOME NUMBERS IN *LACHENALIA* (LILIACEAE)

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ABSTRACT

Chromosome counts are reported for forty-one collections of *Lachenalia*, representing sixteen species and numerous additional undetermined collections, ones of uncertain status, or undescribed species. Chromosome numbers of $n = 5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 18, 22$ and 28 were obtained. Chromosomal races are recorded in some species. For *Lachenalia*, it is probable that $x = 5, 6, 7, 8$ and 9 .

UITTREKSEL

CHROMOSOOMGETALLE IN *LACHENALIA* (LILIACEAE)

Chromosoomgetalle in 41 versamelings van *Lachenalia* word vermeld. Dit sluit 16 soorte en baie ander ongeïdentifiseerde versamelings, soorte van onsekere status en onbeskryfde soorte in. Getalle van $n = 5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 18, 22$, en 28 is verkry. Chromosomaal-rasse is aangetref by sekere soorte. In *Lachenalia* is dit waarskynlik dat $x = 5, 6, 7, 8$, en 9 is.

INTRODUCTION

Lachenalia is a genus of ca. 90 species (Barker, pers. comm.) endemic to South Africa and South West Africa (Namibia); most species occur in the south-western Cape Province in an area with a Mediterranean climate. Though the lines between many species are clear cut, in others there are intergradations and other morphological variation patterns that have led to taxonomic confusion (Moffett, 1936). Two workers have made chromosomal studies of the genus (Moffett, 1936; de Wet, 1957); their counts plus scattered counts made by other workers have revealed chromosome numbers of $2n = 14, 16, 22, 26, 28, 32, 42$, and 56 . During 1970-71, and in 1974, the first author collected *Lachenalia* in the Cape Province, sent the bulbs to Berkeley, and initiated a chromosomal survey of the genus. The results of this survey are reported herein.

MATERIAL AND METHODS

Floral buds of cultivated specimens were fixed in 3:1 glacial acetic acid: absolute ethanol, transferred to 70 % ethanol after fixation, refrigerated, and anthers removed, squashed in acetocarmine. The resultant preparations were examined with a microscope and the number of chromosomes determined.

TABLE 1.

Chromosome numbers in *Lachenalia*.

<i>Species</i>	<i>n</i> =	Author's collection number and locality	Previous reports
aff. <i>algoensis</i> Schoenl.	7	7386: Caledon	
aff. <i>aloides</i> (L.f.) Hort	14	7704: Elgin	
<i>bulbifera</i> Cyrillo	14	7159: Strandfontein	
<i>contaminata</i> Ait.	8	7339: Breërivier	
	8	7377: betw. Worcester and Villiersdorp	
<i>elegans</i> Barker	14	7444: Bulshoek Dam	
	14	7419: Pakhuis Pass	
	28	7417: Pakhuis Pass	
	28	7449: Pakhuis Pass	
aff. <i>fistulosa</i> Bak.	7	7229: Caledon	
	7	7342: Goudini	
<i>hirta</i> Thunb.	11	7137: Ezelfontein	2n = 24 (de Wet, 1957)
<i>juncifolia</i> Bak.	11	7511: Op-Die-Berg	
<i>longibracteata</i> Phillips	7	7095: Mamre Rd. Station	
	7	7431: Bulshoek Dam	
<i>mutabilis</i> Sweet	5	7072: Klawer	2n = 14, 56 (de Wet, 1957)
	5 ^a	7211: Clanwilliam	
<i>orchoides</i> (L.) Ait.	7	7344: Ceres	2n = 16 (de Wet, 1957); 2n = 16, 17 (Moffett, 1936)
	14	7157: Kalbaskraal	
<i>pallida</i> Lindl.	8	7307: Mamre	
	8 ^b	7353: Paarl	
<i>pustulata</i> Jacq.	8	7117: Steenbergs Cove	
<i>purpureo-caerulea</i> Jacq.	8	7522: Darling	
<i>trichophylla</i> Bak.	7	7429: Bidouw Valley	
<i>unicolor</i> Jacq.	8	7130: Kapteinskloof	
	8	7421: Bidouw Valley	
aff. <i>unicolor</i> Jacq.	8	7127: Aurora	
<i>unifolia</i> Jacq.	11	7163: Darling	
	11	7368: Brandvlei Dam	
	11	7515: Citrusdal	2n = 21, 22, 24, 26 (de Wet, 1957)
<i>violacea</i> Jacq.	7	7439: Bulshoek Dam	
Undescribed species:			
aff. <i>hirta</i>	11	7193: Spektakel Pass	
	9	7356: Worcester	
Unidentified species:			
	5	8024: Clanwilliam	
	5	8033: Clanwilliam	
	6	7954: Spektakel Pass	
	8	7952: Okiep	
	8	7973: betw. Vredendal and Vanrhynsdorp	
	8	8044: Pakhuis Pass	
	8	8051: Bidouw Valley	
	9	8036: N11 and Douse the Glim Rd.	

^areciprocal translocation present^bfragment present

RESULTS

Forty-one collections were examined representing 16 species and several undetermined collections, those of uncertain taxonomic status, and two undescribed species. Chromosome numbers of $2n = 10, 12, 14, 16, 18, 22, 28$, and 56 were obtained (Table 1).

DISCUSSION

It is clear that *Lachenalia* is chromosomally more diverse than previously reported, since our counts of $2n = 10, 12$, and 18 are new for the genus. Clearly several base numbers exist: $x = 5, 6, 7, 8$, and 9 . The high diploid numbers can be considered polyploid ones based on various combinations of these base numbers, though it is possible that higher, non-polyploid base numbers may also exist. Few cytological aberrations were noted; a reciprocal translocation was noted in one collection of *L. mutabilis*, and a fragment was observed in a collection of *L. pallida*. For several taxa intraspecific polyploidy exists. Diploids and tetraploids occur in *L. orchioides*; tetraploids and octoploids occur in *L. elegans*. In the latter, populations with the two chromosome numbers occur very near each other. For some species, reports by other workers indicate the existence of chromosomal races at other levels. For example, two collections of *L. mutabilis* had $n = 5$, whereas de Wet (1957) reported $2n = 14$ and 56 for plants attributed to this species. Likewise, in *L. orchioides* and its close relatives, $n = 7$ and 14 are reported herein, whereas both de Wet (1957) and Moffett (1936) reported $2n = 16$; the latter worker also recorded $2n = 17$ for this species. For *L. unifolia*, $n = 11$ is reported from three widely separated populations; de Wet (1957) reported $2n = 21, 22, 24$, and 26 for this species.

Barker (unpub.) has recognized two provisional, major and as yet unnamed groups within *Lachenalia* based on seed characters. All named taxa in Table 1 with $n = 7, 14$, or 28 fall into group 1 except for *L. trichophylla*, which has been assigned to group 2. However, Barker (pers. comm.) states that the seed of *L. trichophylla* is so distinctive that it and several other species with similar seeds may be relegated to still a third group. However, we have obtained $n = 5$ for *L. mutabilis*, also a member of group 1, although de Wet (1957) obtained numbers for this species based on $x = 7$. All species we have examined with $n = 8$ and 11 fall into group 3.

It is thus clear that not only is *Lachenalia* a variable genus in its morphology, but it is also unusually variable in chromosome numbers. The diverse chromosome numbers reported for various species groups in this genus suggest particularly problematical assemblages that merit further cytotaxonomic study.

ACKNOWLEDGMENTS

We are indebted to Dr M. S. Cave and Dr Peter Goldblatt for their assistance with this project. These studies were supported in part by grants from the National

Science Foundation, the Bache Fund of the National Academy of Sciences (both U.S.A.) and the C.S.I.R. We are particularly indebted to Miss W. F. Barker for her continued interest in this project and for providing access to her considerable store of knowledge regarding *Lachenalia*.

REFERENCES

- DE WET, J. M. J., 1957. Chromosome numbers in the Scilleae. *Cytologia* **22**: 145-159.
MOFFETT, A. H., 1936. The cytology of *Lachenalia*. *Cytologia* **7**: 490-498.
RILEY, H. P., 1962. Chromosome studies in some South African monocotyledons. *Can. J. Genet. Cytol.* **4**: 50-55.

TEN NEW SPECIES OF *LACHENALIA* (LILIACEAE)

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ABSTRACT

Ten new species of *Lachenalia* are described, and the characters of the ripe seeds are used for the first time as additional diagnostic features in the genus.

UITTREKSEL

TIEN NUWE *LACHENALIA* SOORTE (LILIACEAE)

Tien nuwe *Lachenalia* spesies word beskryf. Die eienskappe van die ryp sade word as aanvullende diagnostiese kenmerke in die genus *Lachenalia* voorgestel en aangewend.

INTRODUCTION

Since the publication of Baker's monograph on the genus *Lachenalia* in *Flora Capensis* VI, 1896-1897, collections of many new taxa have lain dormant in herbaria, particularly those of Rudolph Schlechter, and many others have been collected in recent years, a number of them apparently, as far as is known, with a very restricted distribution. It is proposed to publish them in sets of ten species, in order to validate the names, to be used in the monograph which is in preparation.

Lachenalia peersii Marl. ex Barker, sp. nov.

Differt a *L. rosea* floribus brevioribus albis urceolatis basi rotundatis, segmentis externis gibbosis viridofuscis, segmentis internis apicibus recurvis, staminibus stylisque inclusis. Seminibus, globosis, arillo inflato, terminale, mensure medio ad longo.

Plant up to 350 mm high, usually less. *Bulb* globose or depressed globose, 20-25 mm diam; outer tunics light brown, membranous. *Leaves* 1-2 lorate, up to 300 mm long and 10-25 mm broad, loosely clasping the base of the peduncle, or sometimes with a clasping base up to 70 mm long, green or tinged with maroon below, and sometimes above. *Peduncle* slender 50-200 mm long, usually dark maroon. *Inflorescence* racemose, few to many flowered, up to 120 mm long and 20-25 mm diam. *Flowers* urceolate, rounded at the base, lax, spreading to slightly cernuous, carnation-scented; pedicels 1.2 mm long; bracts narrow lanceolate, membranous; perianth 7-10 mm long; tube 2-3 mm long, white; outer segments ovate up to 6 mm long, white with greenish brown gibbositities; inner segments obovate up to 8 mm long, with upper edges recurved. white; stamens

Accepted for publication 16th June, 1978.



FIG. 1

Isotype sheet of *Lachenalia peersii*, in Bolus Herbarium No. 16360.

included, as long as the outer segments; ovary globose 3 mm diam., green; style up to 4 mm long. *Capsule* obovate, membranous, 6 mm diam; seeds globose; aril inflated, terminal, narrow, medium to long.

DIAGNOSTIC CHARACTERS

Lachenalia peersii is allied to *L. rosea* Andr. but differs in having the urceolate flowers rounded at the base, and the tips of the inner segments recurved. It is also characterised by having a carnation scent.

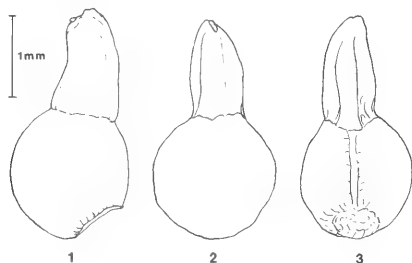


FIG. 2

Lachenalia peersii: 1. seed side view; 2. seed from above; 3. seed from below.

Type Material: CAPE PROVINCE—3419 (Caledon): Hermanus, (-AC), November 1915, *Peers s.n.* sub Herb. Marloth 7263 (PRE, holo.); November 1919 *Peers s.n.* sub. BOL 16360 (BOL, iso.).

This attractive species was collected at Hermanus in 1912 by Mr V. S. Peers, who grew it in his garden in Kenilworth, Cape. In November 1915 he gave flowering specimens to Dr Rudolph Marloth, who preserved them in his herbarium collection, and gave the species the manuscript name *Lachenalia peersii* in honour of its collector. In December 1917 a photograph by Mr Peers, of a pot of bulbs in flower, was published in "South African Gardening and Home Life", with the caption "*Lachenalia peersii* a new variety found in Hermanus and recently named". In November 1919 further specimens from Mr Peers' garden were preserved in the Bolus Herbarium. The sheet was annotated in the hand of Mrs L. Bolus "*Lachenalia peersii* Marl. Typus in Litt" and it was presumed to be a valid species. However as no trace of a description can be found in literature, Dr Marloth's manuscript name has now been validated.

He named it after the man whose name is usually associated with Peers Cave at Fish Hoek, which he and his son Bertie excavated and made famous. It is not generally known that Mr Peers was an enthusiastic and well informed botanical collector of some note, who contributed as many as 700 collections of succulent and bulbous plants to Kirstenbosch, in the early years after it was established.

The species is widely distributed in the south western part of the Caledon district, where it occurs in rocky ground. Out in the open it is often rather stunted, but plants flowering on recently burnt ground can become strong and robust.

SPECIMENS EXAMINED

CAPE PROVINCE—3418 (Simonstown): Palmiet River Bridge (-BD), 30/10/1962, *Thomas s.n.sub.* NBG 70017 (NBG); Sunny Seas, 29/9/1967, and 27/10/1967, *Barker 10516* (NBG); Harold Porter Botanic Gardens, Bettys Bay, 27/10/1970, *Ebersohn s.n.sub.* NBG 92682 (NBG); Disa Kloof, Bettys Bay, 9/12/1966, (fruiting); 1/11/1968, (flowering) *Rourke 686* (NBG); Hangklip, 8/12/1965, (fruiting) *Barker 10368* (NBG); Waterfall Kloof, Hangklip Nov. 1948, *Stokoe s.n.sub.* SAM 61313 (SAM).

—3419 (Caledon): 12 m. W of Caledon (-AB), 17/9/1934, *Salter 4861* (BM, BOL, K); Hermanus (-AC), Nov. 1915, *Peers s.n.sub.* Herb. Marloth 7263 (PRE, holo); Nov. 1919, *V. S. Peers s.n.sub.* BOL 16360 (BOL); Nov. 1921, *Rogers s.n.sub.* PRE 26566 (PRE); 8/11/1963, *Thomas and Barnard s.n.sub.* NBG 70714 (NBG); Hermanuspetrusfontein, 23/10/1897, *E. E. Galpin 4755* (PRE, K); Riviera Hotel Flats, 10/10/1916, *Purcell 107* (SAM); 4/10/1918, *Purcell s.n.sub.* (SAM); near Hermanus, 16/10/1966, *Barker 10484* (NBG); Voelklip Kloof, 18/11/1973, *Esterhuysen 33357* (NBG); Voelklip Bot.Soc. Reserve, 22/10/1969, *Rourke s.n.sub.* NBG 93557 (NBG); Onrust River, 1/12/1951, *Esterhuysen 19268* (BOL); Shaws Mt, Sept. 1938, *Gillett 4464* (BOL, K); De Wets Bay, Kleinmond, 1/11/1968, *Barker 10515* (NBG).

***Lachenalia multifolia* Barker, sp. nov.**

Distinguitur foliis numerosis filiformibus teretibus pallide viridibus basi albis succulentis, inflorescentia racemosa multiflora, pedicellis brevis patulis, floribus campanulatis albis, segmentibus leviter cucullatis fere aequantibus pallide viridibus gibbosis, staminibus perspicue exsertis rectis, seminibus globosis, arillo jugoso terminale perbreve.

Plant 70–200 mm high, usually dwarf. *Bulb* globose 10–20 mm diam., outer tunics papery, brownish. *Leaves* 5–13, usually as long or a little longer than the peduncle, occasionally longer, 150–170 mm long; blade filiform terete, yellow-green, broadening into white, fleshy, flattened bases 20–30 mm long and 5–8 mm broad. *Inflorescence* racemose many-flowered up to 70 mm long and 30–50 mm diam.; peduncle slender, green or tinged with red; pedicels spreading up to 10 mm long, usually shorter. *Flowers* strongly scented, spreading; perianth 8 mm long; tube 3 mm long, white; outer segments oblong 5,5 mm long, 3 mm wide, white with pale green gibbositities; inner segments as long as outer, narrow oblong, white with green keels, all segments slightly spreading with the apex slightly cucullate; stamens exserted evenly spaced up to 7 mm long; ovary ovoid 3,5 mm long pale

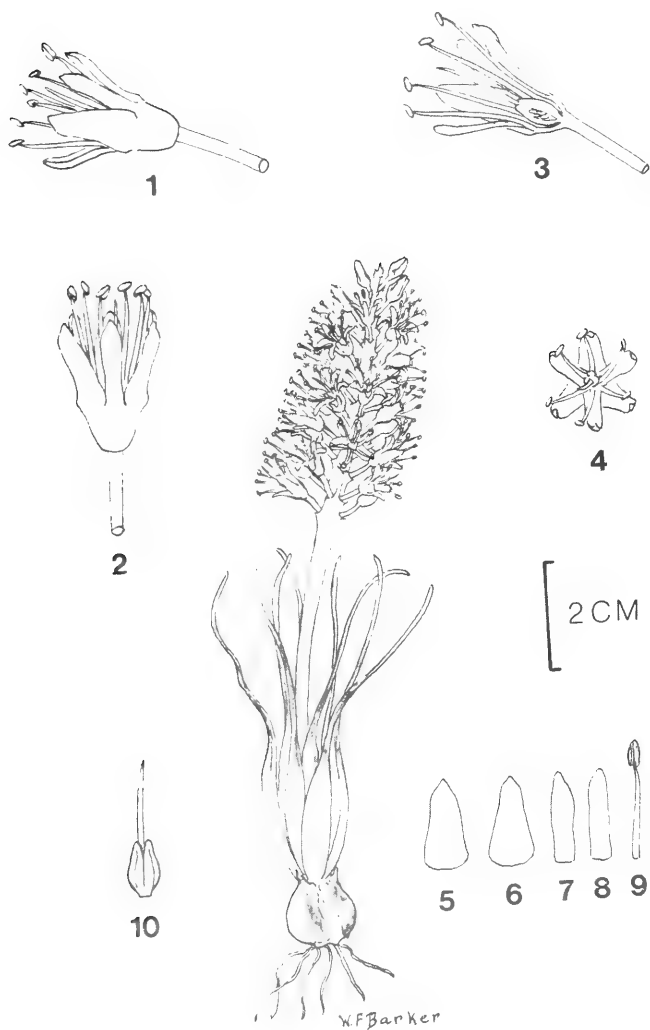


FIG. 3

Lachenalia multifolia: 1. flower side view; 2. flower from below; 3. transverse section of flower; 4. flower front view; 5. lateral outer perianth segment; 6. upper outer perianth segment; 7. lateral inner perianth segment; 8. lower inner perianth segment; 9. stamen; 10. gynoecium, all $\times 3$.

green; style finally as long as stamens. *Capsule* obovate membranous 5 mm diam., 1–2 seeds in each loculus; seed ovoid, aril very short, ridged terminal.

DIAGNOSTIC CHARACTERS

Lachenalia multifolia most closely resembles *L. polyphylla* but is distinguished by having the swollen bases of the leaves white and smooth, the white flowers are campanulate with the segments slightly spreading and cucullate, while those of *L. polyphylla* are tinged maroon, urceolate, with the tips of the inner segments recurved.

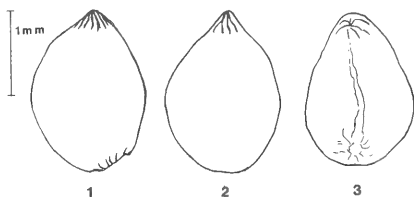


FIG. 4

Lachenalia multifolia: 1. seed side view; 2. seed from above; 3. seed from below.

Type Material: CAPE PROVINCE—3319 (Worcester): Karoo Poort (-BA), 26/9/1944, Barker 3053 (NBG, holo.).

Lachenalia multifolia is one of only five species in the genus having many leaves. It resembles *L. polyphylla* superficially but is very distinct when compared in detail, and their habitats differ widely; it is found on rocky hillsides, in rock pans and rock crevices, while *L. polyphylla* favours flat open ground. The distribution of the species too is widely separated, *L. multifolia* occurs in the Worcester, Ceres, and Calvinia districts, while *L. polyphylla* is only known from the Malmesbury, Piketberg and Tulbagh districts. The two species differ considerably in the characters of their seeds, *L. multifolia* has a seed with a very small ridged aril, that of *L. polyphylla* is covered entirely by an irregular pattern of ridges.

SPECIMENS EXAMINED

CAPE PROVINCE—3119 (Calvinia): 10 m N. of Calvinia (-BD), 25/9/1962 Levyns (NBG).

—3319 (Worcester): Ceres (-AD), 9/1925, Nielson *s.n.* sub. Hort. NBG 1008/25 (BOL); Ceres Karoo 10/1931 H. Herre *s.n.* sub Hort. Stell. Univ. Gdns 3844 (BOL); Karoo Poort (-BA) 26/9/1944, Barker 3053 (NBG holo.); 22 m N. of Karoo Poort, 19/9/1954, H. Hall 947 (BOL);

—3320 (Montagu): Constable, 4/10/1940 (-AD), Compton 9737 (NBG); 10/1940, Esterhuysen 5083 (BOL).

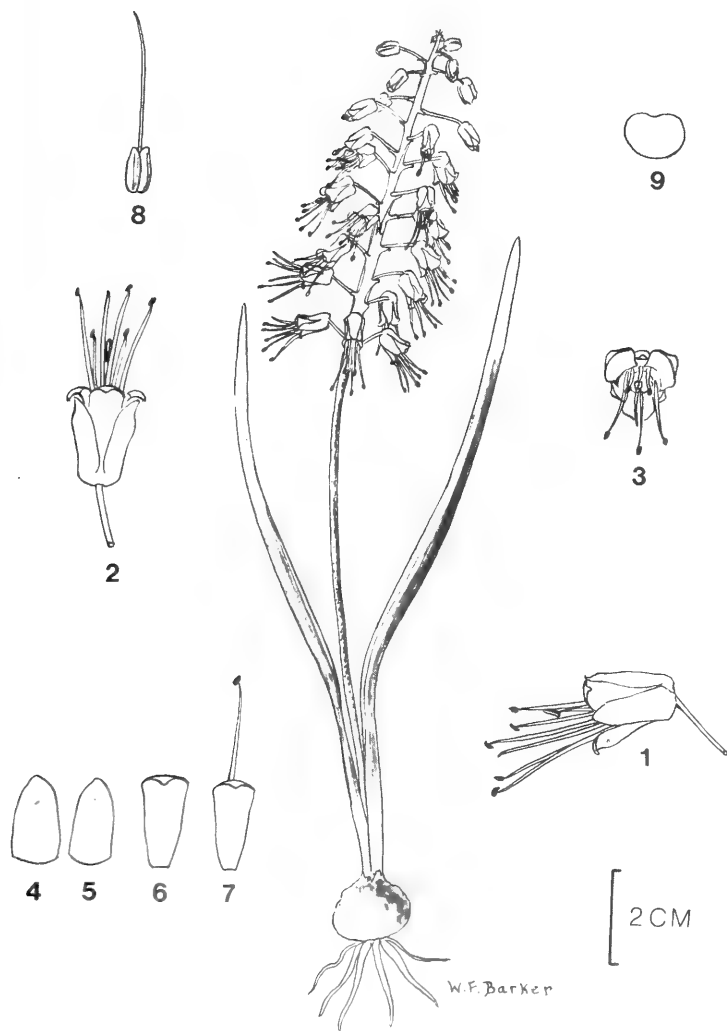


FIG. 5

Lachenalia esterhuysenae: 1. flower side view; 2. flower from below; 3. flower front view; 4. upper outer perianth segment; 5. lateral outer perianth segment; 6. lateral inner perianth segment; 7. lower inner perianth segment; 8. gynoecium; 9. transverse section of leaf, all $\times 3$.

***Lachenalia esterhuysenae* Barker, sp. nov.**

Distinguitur foliis 1–2 longis linearibus teretibus venetis basi supra canaliculatae, pedunculo longo gracile, inflorescentia laxo, pedicellis longis patulis, floribus cremeis campanulatis cernuis, staminibus perspicue exsertis. Seminibus ovoideis, arillo jugoso, terminale, minuto.

Plant 150–450 mm high. *Bulb* globose or depressed globose 12–18 mm diam., with soft brown outer tunics, not produced into a neck. *Leaves* 1–2, linear, terete, with a shallow channel down the upper face toward the base, scarcely clasping the base of the peduncle, erect with the support of surrounding vegetation, 140–360 mm long, up to 5 mm diam., blue-green, shading to reddish-brown near the base, without markings. *Peduncle* up to 340 mm long, very slender, tinged or minutely spotted with reddish-brown. *Inflorescence* racemose 40–110 mm long many-flowered, sterile portion very short, flowers lax, cernuous; bracts very small, apex narrow lanceolate, membranous, translucent; pedicels 4–10 mm long, very slender, spreading, cream. *Flowers* 4–6 mm long, 3 mm diam. at base, cernuous, campanulate, rounded at the base; tube 1 mm long, cream; outer segments 3–4 mm long, slightly spreading, cream with green gibbosities; inner segments slightly longer than the outer up to 5 mm long, slightly spreading, cream with a greenish blotch near the apex, upper edge of margin recurved with a small central cusp; stamens well exserted up to 13 mm long; ovary ovate, up to 3 mm long, green; style exserted up to 12 mm long. *Capsule* obovoid, membranous, 3 mm diam. seeds shining, ovoid, aril ridged, terminal, minute.

DIAGNOSTIC CHARACTERS

Lachenalia esterhuysenae is easily recognized by its small, cernuous, cream flowers with well exserted stamens, and long spreading pedicels, and by its very long, blue-green, filiform, terete leaves.

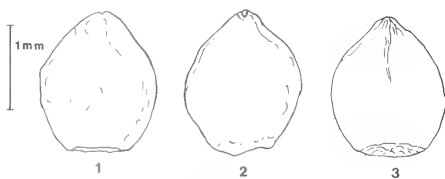


FIG. 6

Lachenalia esterhuysenae: 1. seed side view; 2. seed from above; 3. seed from below.

Type Material: CAPE PROVINCE—3219 (Wuppertal): S. Cedarberg, Sneeuwberg Area, above Bakleikraal (-AC), *E. Esterhuysen* 34149 (BOL, holo.; K, iso.; NBG, iso.; MO, iso.; PRE, iso.; S, iso.).

This interesting high altitude species was first collected on 30th September 1940 in the Pakhuis Pass by Miss E. E. Esterhuysen, while on a journey to

Calvinia to witness the total eclipse of the sun. Only one flowering bulb was collected, which was later illustrated. A second small collection was made on 11th December 1950, also by Miss Esterhuysen, at the northern end of the Cedarberg Sneeuwkop, below the shale band at 1 200 m, extending its known range somewhat. It was found again in the first locality on 19th October 1965, when Mrs M. Thomas and Miss W. Barker were travelling through the Pakhuis Pass. The plants were growing at about 900 m on a rocky slope, appearing through low fynbos, and the peduncles and leaves were elongated to penetrate to the light. Bulbs were grown and ripe seed was collected on 30th November 1965. On 11th December 1975 another extensive collection was made by Miss Esterhuysen, at the southern end of the Cedarberg Sneeuwberg, above Bakleikraal, below the shale band at 1 200 m. It consisted of flowering and young fruiting plants some of which were grown, and produced mature seeds in December 1976. It is named in honour of Miss E. E. Esterhuysen, who was Botanical assistant at the Bolus Herbarium for many years, and has always been most helpful and generous in supplying material and information, particularly of high altitude species.

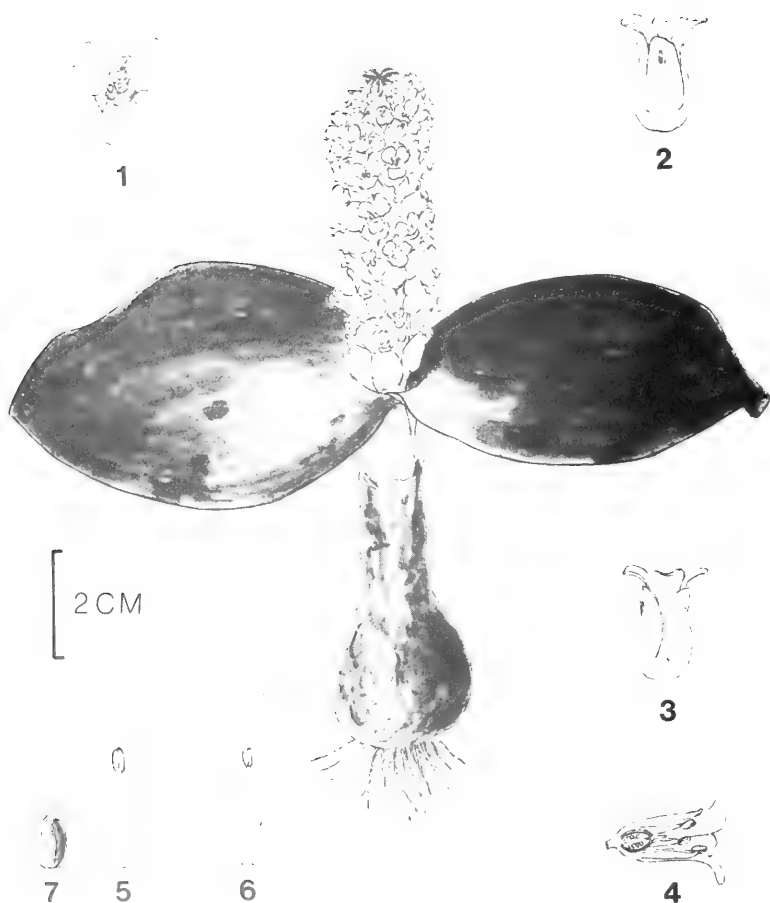
SPECIMENS EXAMINED

CAPE PROVINCE—3219 (Wuppertal): Pakhuis Pass, Clanwilliam, (-AA), 3/9/1940, *E. Esterhuysen s.n.* sub NBG 72233 (NBG); 19/10/1965, *Barker 10319*; Cedarberg Sneeuwberg (-AC), 11/12/1950, *E. Esterhuysen 18023* (BOL); S. Cedarberg area above Bakleikraal, 11/12/1975, *E. Esterhuysen 34149* (BOL, holo.; K, iso.; NBG, iso.; MO, iso.; PRE, iso.; S, iso.).

Lachenalia congesta Barker, sp. nov.

Distinguitur foliis 2 ovatis oblongis prostratis supra atroviridis infra maroninos, inflorescentia spicato congesto, pedunculo brevissimo saepe non suprateraneo, floribus cremeis gibbosis virido-fuscis, segmentibus internis pellucidis apice recurvatis, staminibus inclusis, seminibus ovoideis, arillo jugoso terminale, perbreve, testa foveolata.

Plant 80–140 mm high, dwarf. *Bulb* obovate, 15–24 mm diam. with light brown, spongy outer tunics produced into a long neck up to 40 mm long; leaf-sheath obtuse, transparent, extending above the neck. *Leaves* 2, resembling those of *Massonia*; blade thick, ovate to oblong, subacute, prostrate 35–75 mm long and 34–56 mm wide, dark green or tinged with maroon, sometimes with a few irregular blotches above, suffused with maroon below, margin maroon; bases white, clasping the peduncle. *Inflorescence* a very dense spike 25 mm diam., up to 70 mm long, flowers suberect to spreading, strongly scented; peduncle very short often none above ground. *Bracts* narrow-lanceolate, up to 5 mm long membranous, white. *Flowers* sessile up to 13 mm long; tube 3 mm long, very pale blue; outer segments 7 mm long, ovate erect, white shading to pale yellow with green



G. J. Lewis.

FIG. 7

Lachenalia congesta: 1. flower front view $\times 3$; 2. flower side view $\times 2$; 3. flower from below $\times 2$; 4. transverse section of flower $\times 2$; 5. outer perianth segment and stamen $\times 3$; 6. inner perianth segment and stamen $\times 3$; 7. gynoecium $\times 3$; Del G. J. Lewis.

gibbosities and pellucid recurved apices; inner segments 10 mm long, narrow oblong emarginate, cream shading to yellow with green keels, pellucid apices recurved; stamens included, 5 mm long, filaments white; ovary oblong up to 4 mm long, green; style usually short 2–3 mm long, white. *Capsule* obovate, carpels each with a portion of the persistent style forming a cusp at the apex; seed comparatively large, globose with a much reduced conical ribbed aril, the surface apparently with a depressed pattern. (Only one capsule and one seed was produced).

DIAGNOSTIC CHARACTERS

Lachenalia congesta is a very distinctive species, with its dense inflorescence and prostrate leaves. It belongs to the group of plants which have seeds with the aril almost completely reduced. It appears to be most closely allied to *L. isopetala*, another very distinct species, as their seeds are similar in shape and the largest in the group.

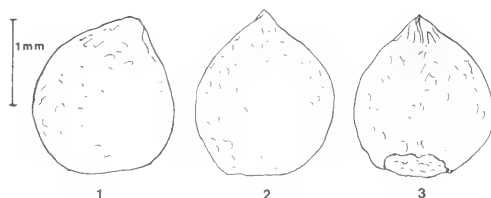


FIG. 8

Lachenalia congesta: 1. seed side view; 2. seed from above; 3. seed from below.

Type Material: CAPE PROVINCE—3220 (Sutherland): Sutherland (-BC), 8/7/1968, *F. Stayner s.n.* sub. NBG 93575 (NBG, holo.); 18/6/1970, *Stayner s.n.* sub. NBG 93574 (NBG, iso.).

The earliest record of this unusual and interesting species with its congested inflorescence emerging from two prostrate, broad, dark green leaves, was made by Mr P. Ross-Frames, who collected it at Muldersfontein 10 miles west of Middelpos, in the Calvinia district, on 7th August 1933. He brought it to the Bolus Herbarium, where Miss G. J. Lewis made the accompanying painting. She noted that the leaves lying flat on the ground resembled those of a *Massonia*. When not in flower they could very well be mistaken for one. About 20 years later it was collected S.S.E. of Sutherland by Acocks, and in 1955 by Leistner. On the 8th of August 1968 another collection, this time in bud, was brought to the Compton Herbarium by Mr F. Stayner, for many years Curator of the Worcester Karoo Botanic Garden, also collected at Sutherland. Bulbs flowered in a pot on the 22nd of July 1968 and again on the 18th June 1970. Only one capsule matured,

and one seed developed, which had a very reduced aril, and the testa appeared to have a depressed pattern on it. The plant according to Acocks grows in shale gravel, in mountain Rhénosterveld.

SPECIMENS EXAMINED

CAPE PROVINCE—3120 (Williston): near Muldersfontein, 10 m W. of Middelpoos (-CC), 7/8/1933, *P. Ross-Frames s.n.* sub. BOL 21365 (BOL).

—3220 (Sutherland): Sutherland (-BC), 8/7/1968, *Stayner s.n.* sub. NBG 93575 (NBG, holo.); 18/6/1970, *Stayner s.n.* sub. NBG 93574 (NBG, iso.); 14 m S.S.E. of Sutherland (-BD), 24/8/1953, *Acocks 16935* (K); 19.5 m S.S.E. of Sutherland, 1/9/1955, *Leistner 281* (K).

Lachenalia namaquensis Schltr. ex Barker, sp. nov.

Distinguitur foliis 1–2 linearibus lanceolatis canaliculatis ad apicem semiteretibus, inflorescentia spicata, floribus rectis vel patulis, periantho externo urceolato tubo caeruleo segmentis magenteis, segmentibus internis longioribus patentibus recurvatis supernis albis inferiore magenteo, staminibus segmentibus internis brevioribus, seminibus globosis, arillo jugoso, terminale, breve.

Plant up to 230 mm high. *Bulb* globose, small 10–15 mm diam.; outer tunics thin, membranous, russet-brown, produced into a short neck; bulbils produced at soil level from a few stolons from the base. *Leaves* 1–2, linear-lanceolate, up to 140 mm long; clasping base up to 60 mm long white, blade green, conduplicate or with inrolled margins, narrowing to the semiterete apex. *Peduncle* slender up to 120 mm long. *Inflorescence* spicate up to 100 mm long, 20 mm diam., few to many flowered; bracts very small, subobtus. *Flower* suberect to spreading; perianth 8–11 mm long, narrow urceolate; tube 2–3 mm long, bright blue; outer segments 5 mm long, ovate, subacute, magenta with maroon-purple gibbosities; inner segments up to 9 mm long, oblanceolate, narrowing to the base, the two upper overlapping, spreading at the apex, shining white, tinged magenta at the apex; lower segment narrower, deep magenta, apex recurving; stamens a little shorter than the inner segments; ovary ovate 2–3 mm diam. style up to 6 mm long. *Capsule* oblong, membranous, 5 mm diam.; seeds globose, aril ridged, short, terminal.

DIAGNOSTIC CHARACTERS

Lachenalia namaquensis is characterised by its one to two leaves, which have linear lanceolate, conduplicate blades, narrowing to a semiterete apex. The flowers are sessile, narrow urceolate, usually blue at the base, shading to magenta, the inner segments are longer than the outer, the upper two are white while the lower one is deep magenta. (A colour form with rose coloured flowers was found at Klipfontein by Mr J. W. Mathews on 27th October 1930.) The bulb produces

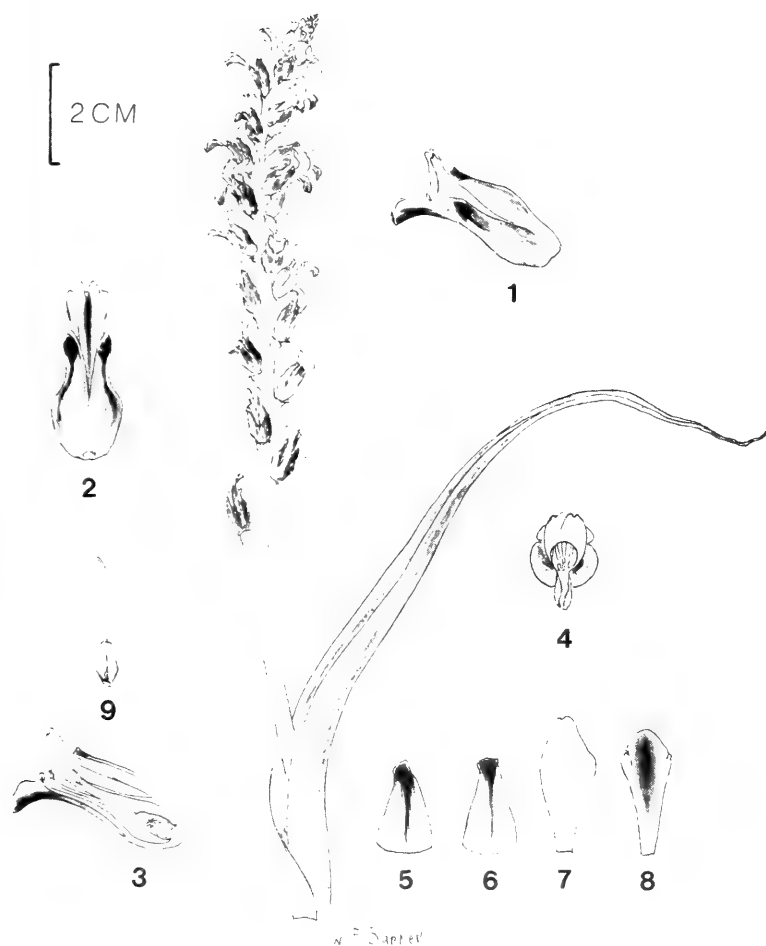


FIG. 9

Lachenalia namaquensis: 1. flower side view; 2. flower from below; 3. transverse section of flower; 4. flower front view; 5. lateral outer perianth segment; 6. upper outer perianth segment; 7. lateral inner perianth segment; 8. lower inner perianth segment; 9. gynoecium, all $\times 3$.

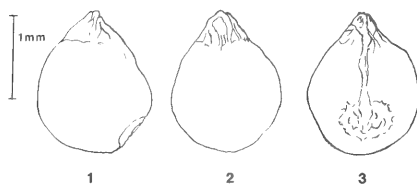


FIG. 10

Lachenalia namaquensis: 1. seed side view; 2. seed from above; 3. seed from below.

bulbils at ground level, on long stolons from the base of the bulb, and the plants are usually found in colonies.

Type Material: CAPE PROVINCE—2917 (Springbok): 6 m S. of Steinkopf, (-BD), 23/8/1959, *Barker 9020* (NBG, holo.).

Lachenalia namaquensis was collected by Rudolph Schlechter as early as 23rd September 1897, and he distributed it to many herbaria under its manuscript name. As its distribution appears to be confined to Namaqualand, the name is appropriate and it is now validated.

It is most closely allied to *L. framesii* Barker which differs from it in having shorter yellow flowers, with all the inner segments tipped with deep magenta, and the leaves are lanceolate with undulate margins. The seeds in the two species are similar.

In its natural habitat *L. namaquensis* is a dainty dwarf species, which increases rapidly by means of bulbils on long stolons, and it usually occurs in colonies. In 1959 it was found growing in mass, in pockets on huge granite boulders near Steinkopf, and more recently in stony clay soil, or in sandy soil, in other localities.

SPECIMENS EXAMINED

CAPE PROVINCE—2816/—2817 (Oranjemund/Vioolsdrif): Richtersveld, 26/8/1931, *Herre s.n.* sub. Hort. SUG 3862 (BOL); 9/9/1936 *Herre s.n.* sub. Hort. SUG 3902 (BOL).

—2917 (Springbok): Steinkopf-Klipfontein (-BA), 26/8/1931, *Herre s.n.* sub. Hort. SUG 3836 (BOL); Steinkopf-Obob, Sept. 1935, *Herre s.n.* sub. Hort. SUG 3856 (BOL); 4 m N.W. by W. of Steinkopf, 21/9/1957, *Acocks 19529* (NBG); Klipfontein, Oct. 1930 and 1931, *Mathews s.n.* sub. Hort. NBG 2228/29 (BOL), Oct. (colour var.); Oct. 1926, *Pillans 5712* (BOL); Steinkopf (-BA/-BC), 23/9/1897, *R. Schlechter 11383* (B, BOL, G, GRA, K, LD, PRE, Z), 18/9/1933, *Salter 3755* (BOL); Steinkopf-Platteklip, *Herre s.n.* sub. Hort. SUG 3862 (BOL); 1 m W. of Steinkopf, 19/10/1971 and 19/10/1973, *Hall 4175* (NBG), 26/8/1931, *Herre s.n.* sub. Hort. SUG 3837 (BOL); 6 m S. of Steinkopf (-BD), 23/8/1959, *Barker 9020* (NBG, holo.); Spektakel Mt. (-DA), 26/9/1974, *Goldblatt 2788*

(NBG); 14 m W. by S. of Springbok, 24/9/1957, *Acocks 19571* (NBG); 4 m E. of Springbok (-DB), 15/9/1948, *Salter s.n.* sub. NBG Hort. 2075/1933 (NBG).

***Lachenalia verticillata* Barker, sp. nov.**

Distinguitur folio unico glauco-viridi falcati vel lanceolati conduplicati infra maculati basi amplexantibus fasciatis, inflorescentia spicata floribus patentibus in quoque verticillo tres, periantho externo urceolato tubo caeruleo segmentibus pallidis, segmentibus internis longioribus patulis recurvatis apice magenteis, staminibus segmentibus internis brevioribus, seminibus globosis arillo jugoso terminale mensure medio.

Plant up to 250 mm high. *Bulb* globose up to 20 mm diam., outer tunics spongy, brown; basal sheath membranous, obtuse, up to 20 mm long. *Leaf* 1, falcate to lanceolate, conduplicate; blade spreading, up to 90 mm long and 20 mm broad, blue-green, blotched with purple on the lower side, margin undulate; clasping base up to 50 mm long, banded with purple above shading to magenta at the base. *Peduncle* slender up to 90 mm long. *Inflorescence* spicate, up to 100 mm long and 20–25 mm diam.; flowers in verticils of three, spreading; bracts very small. *Flowers* 9–12 mm long, urceolate; tube 3 mm long dull blue; outer segments paler, ovate convex, subacute, 6 mm long and 5 mm broad; lateral inner segments obovate oblong, 10 mm long, 3 mm broad near the apex, with purple recurved tips; lower inner segment slightly longer and conduplicate with a purple recurved tip; stamens included, 6 mm long; ovary globose, 2 mm long; style 6 mm long. *Capsule* globose 6 mm diam.; seed globose aril ridged, terminal, medium length.

DIAGNOSTIC CHARACTERS

Lachenalia verticillata is distinguished by its single falcate to lanceolate conduplicate leaf which is spotted on the lower side of the blade, banded on the clasping base and the sessile flowers are arranged in three-flowered verticils. The outer perianth is urceolate and broadest at the base, and the inner segments are longer, spreading, recurved, and tipped with purple.

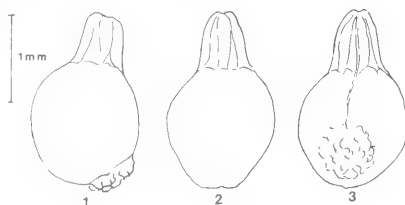


FIG. 12

Lachenalia verticillata: 1. seed side view; 2. seed from above; 3. seed from below.



FIG. 11

Lachenalia verticillata: 1. flower side view; 2. flower from below; 3. flower front view; 4. transverse section of flower; 5. lateral outer perianth segment; 6. upper outer perianth segment; 7. gynoecium, $\times 3$.

Type Material: CAPE PROVINCE—2917 (Springbok): 3 m S.E. of Steinkopf, 18/9/1933, Salter 3746 (BOL. holo.; BM, iso.; K, iso.).

Only two collections have been made of this unique species, in spite of the fact that it flowers in September when many people visit the area in a good flower season. It was first collected by H. Bolus near O'Okiep in September 1833. The second collection was made fifty years later, in September 1933 by Paymaster Captain T. M. Salter who found it not very far from the original locality, at Springbok, in Namaqualand.

SPECIMENS EXAMINED

CAPE PROVINCE—2917 (Springbok): 3 miles S.E. of Springbok (-BA/-BC), 18/9/1933, Salter 3746 (BOL, holo.; BM, iso.; K, iso.); Near O'Okiep (-DB), 9/1883, H. Bolus 6590 (BOL, K, SAM).

Lachenalia concordiana Schltr. ex Barker, sp. nov.

Distinguitur folio unico, lamina angusta lineari conduplicato curvato, basi amplexententi viridi fasciata, floribus sessilibus late campanulatis, staminibus segmentibus internis aequantibus, seminibus oblongis, arillo jugoso, terminale, mensura medio.

Plant up to 200 mm high. *Bulb* obovate, 12–20 mm diam.; with many dark brown tunics produced into a neck up to 25 mm long. *Leaf* 1, up to 120 mm long; blade narrow linear-lanceolate, conduplicate, spreading, curved, green up to 80 mm long; clasping base slender, banded with green in the upper half, up to 70 mm long. *Peduncle* short, up to 40 mm long above the clasping base. *Inflorescence* spicate 20–100 mm long, up to 20 mm diam., few to many flowered, flowers spreading, and usually arranged in three-flowered verticils. *Flowers* widely campanulate 9–12 mm long; tube 3 mm long (colour not recorded); outer segments 7 mm long ovate acute spreading slightly, tips recurved; inner segments 9 mm long, the two lateral obovate, subacute overlapping, recurving at the apex; lower ovate acute spreading to form a lip; stamens as long as the inner segments; ovary ovoid 4 mm long; style finally longer than the stamens. *Capsule* membranous 8 mm long, ovate; seed oblong, aril ridged, terminal, of medium length.

DIAGNOSTIC CHARACTERS

Lachenalia concordiana is distinguished by its single leaf with a narrow linear lanceolate, conduplicate blade, and the clasping base banded with green. The spicate inflorescence has the widely campanulate flowers arranged in three-flowered verticils.

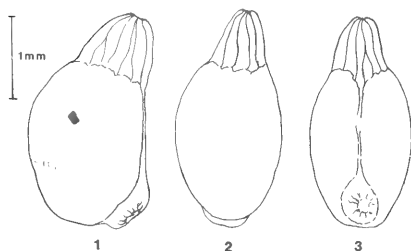


FIG. 14

Lachenalia concordiana: 1. seed side view; 2. seed from above; 3. seed from below.

Type Material: CAPE PROVINCE—2917 (Springbok): 15 m N.E. of Springbok (-DB), 8/9/1950, *Barker* 6762 (NBG, holo., iso.).

Until recently only two collections of this distinctive species were known. The original one, collected on 19th September 1897 by R. Schlechter, at Concordia in Namaqualand, was distributed to many herbaria under his manuscript name, now validated. The second was made by W. F. Barker on 8th September 1950 near Springbok. The discovery of a third collection among the incertae in the Bolus Herbarium, collected by C. L. Leipoldt in September 1941 near Garies, a considerable distance to the south, indicates that the species has a wider distribution than was at first thought. Fortunately this material includes capsules with ripe seeds, which were absent in the earlier collections; these assist in placing the species in the group with ridged, terminal arils.

SPECIMENS EXAMINED

CAPE PROVINCE—2917 (Springbok): Concordia (-DB), 19/9/1897, *Schlechter* 11322 (B, BM, G, GRA, K, LD, Z); 19/9/1897, *Schlechter* 11321? (PRE); 15 m N.E. of Springbok, 8/9/1950, *Barker* 6762 (NBG holo., iso.). —3018 (Khamiesberg): near Garies (-CA), Sept., 1941, *G. L. Leipoldt* 3575 (BOL).

Lachenalia glaucophylla Barker, sp. nov.

Distinguitur folio unico glauco anguste lanceolato conduplicato patentis vel curvatis, basi amplexentis, inflorescentis racemosa angusta multiflora, floribus patulis cremeis late campanulatis, segmentibus fere aequantibus, staminibus rectis perspicue exsertis. seminibus oblongis, arillo jugoso terminale stature medio vel breve, in carina angusta decurrente prolongata.

Plant 90–250 mm high, usually dwarf. *Bulb* globose 10–20 mm diam., outer tunics spongy, brown, disintegrating, produced into a short neck. *Leaf* usually 1,

very occasionally 2, narrow-lanceolate, conduplicate; blade up to 130 mm long, usually less, up to 14 mm at ground level, spreading or curved almost at right angles, glaucous green without markings; clasping base up to 70 mm long, white, surrounded by a membranous transparent sheath up to half its length. *Peduncle* usually very short, occasionally up to 60 mm long above ground level, tinged with brown. *Inflorescence* racemose, narrow, 20 mm diam., up to 80 mm long, many-flowered, flowers spreading; bracts minute, obtuse, membranous; pedicels 2–3 mm long, spreading, cream. *Flowers* very small, up to 5 mm long; tube 0.5 mm long, cream; outer segments 4 mm long, ovate, spreading, cream with green gibbosities; inner segments 5 mm long, narrow oblong, spreading, cream with green keel; stamens exerted 7 mm long, spreading, filaments cream; ovary globose 1–2 mm diam., green; style 3–5 mm long. *Capsule* globose 4 mm diam., membranous, about 2 seeds to each loculus; seeds oblong, comparatively large, shining, aril terminal, short or medium, extending as a narrow ridge down to the ridged micropyle.



FIG. 15 a, b.

Lachenalia glaucophylla: a. two plants, one in bud; b. inflorescence close up; c. plants in bud.

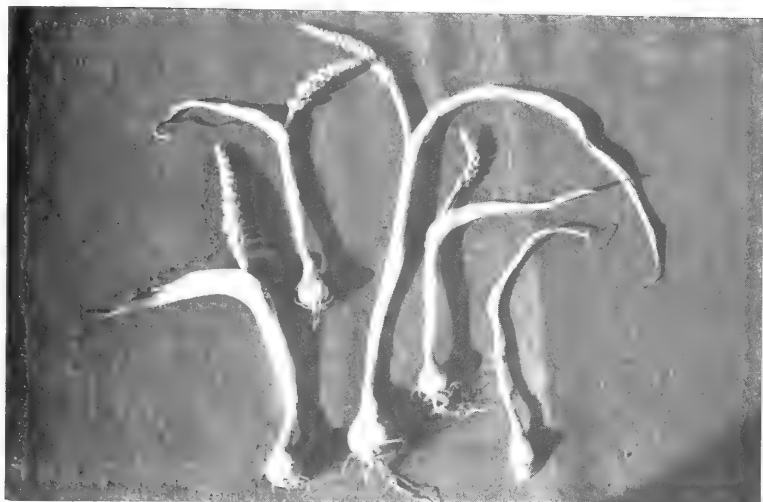


FIG. 15 c.

DIAGNOSTIC CHARACTERS

Lachenalia glaucophylla is easily distinguished by its 1 (or very occasionally 2) linear-lanceolate conduplicate, curved, glaucous leaf, its dense narrow racemose inflorescence composed of very small cream flowers, with spreading segments of almost equal length, and much exerted spreading stamens. Its seed is ovoid, with a terminal, short or medium ribbed aril.

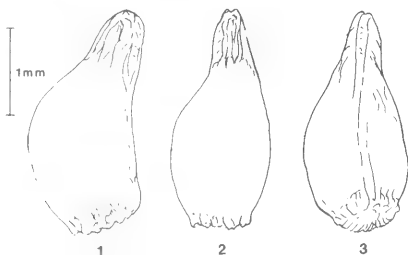


FIG. 16

Lachenalia glaucophylla: 1. seed side view; 2. seed from above; 3. seed from below.

Type Material: CAPE PROVINCE—3319 (Calvinia): 11 miles from Downes on Klipwerf road (-BD), 14/10/1974, *M. Thomas s.n.* sub. NBG 105737 (NBG, holo.).

The earliest collection of this dainty new species to be traced, was collected by Dr. Rudolph Marloth in October, 1917 at Leliefontein in Namaqualand, and is

preserved in the National Herbarium, Pretoria. It consists of two very small specimens in the young fruiting stage, which made its identification difficult. More recent collections representing all stages, including good flowering material have been made, and it is now possible to decide that they represent a previously undescribed species, which is distinctive in leaf and floral characters. The seeds belong to the large group with ribbed arils.

It was found growing in colonies on open flats with sparse vegetation, in very shallow pans where silt had collected. The recent collections have all been made in the Calvinia district, some distance from the Marloth specimens, thus extending the known distribution of the species considerably. The fact that it flowers in October may account for the fact that it has not been more widely collected.

SPECIMENS EXAMINED

CAPE PROVINCE—3018 (Kamiesberg): Kamiesbergen, Leliefontein (-AC), 9/1917, *Marloth 8101* (young fruits) (PRE).

—3319 (Calvinia): Moordenaarspoort, 26 miles N.E. of Calvinia near Agter Hantamsberg (-BD), 6/10/1953, *G. J. Lewis 2630* (SAM); 11 miles from Downes on Klipwerf road, 14/10/1974, *M. Thomas s.n.* sub. NBG 105737 (NBG, holo.).

—3120 (Williston): 40 m E. of Calvinia on Williston road (-AC), 13/10/1976, *Barker 10554* (young fruit) (NBG).

Lachenalia sargeantii Barker, sp. nov.

Distinguitur foliis 2 linearibus lanceolatis conduplicatis patentibus, inflorescentia racemosa, pedunculo atro-marronino, pedicellis longis patulis magenteis, floribus cremeis pendulis tubulosis basi rotundatis magenteis suffusus, segmentis externis gibbosis viridofuscis, segmentis internis longioribus apice macula viridofusca, staminibus inclusis, seminibus globosis, arillo membranoso terminale breve in carina decurrente lato prolongata, testa colliculata.

Plant 200–300 mm high. *Bulb* 15–20 mm diam. with dark brown leathery tunics, producing a nest of bulbils round the base of the bulb. *Leaves* 2, linear-lanceolate, conduplicate, loosely clasping the base of the peduncle, suberect to spreading, up to 300 mm long and 15 mm broad, yellow-green to bluish-green, without markings. *Peduncle* 140–280 mm high, much longer than the raceme, dark maroon and faintly blotched and lightly glaucous. *Inflorescence* racemose, 6–25 flowered; flowers pendulous concentrated into a head, sterile portion at apex very short; bracts white or tinged with magenta, ovate lanceolate, short up to 4 mm long; pedicels to lower flowers shorter, about 4 mm long, increasing in length upwards to 15 mm long spreading to recurved, magenta. *Flowers* up to 25 mm long, pendulous, tubular, rounded at the base and slightly constricted about 3 mm above the base; tube 3–4 mm long; outer segments up to 15 mm long, oblong lanceolate, cream with greenish-brown gibbositities; inner segments longer than the

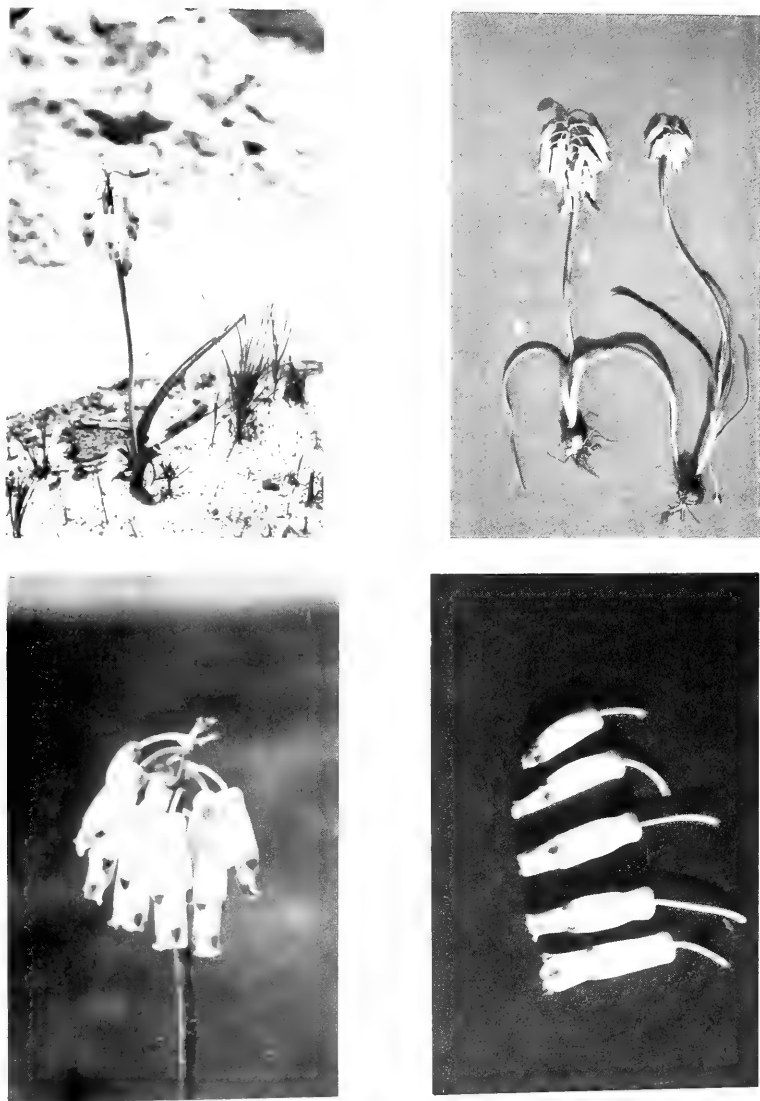


FIG. 17 a, b, c, d.
Lachenalia sargeantii: a. habitat; b. two plants; c. inflorescence; d. flowers.

outer, up to 20 mm long, 7 mm broad near the apex, slightly emarginate, cream with a greenish-brown blotch near the apex, and a magenta keel; stamens a little shorter than the inner segments; ovary obovoid, 3 mm diam., green; style finally exserted. *Capsule* obovoid, membranous 5 mm diam; seed black, globose with a narrow membranous decurrent aril widening toward the funicle, testa colliculate.

DIAGNOSTIC CHARACTERS

The long cream, pendulous, tubular flowers which are rounded at the base and slightly constricted above it, are grouped at the apex of the long peduncle, on long magenta pedicels, a character which is unusual in the genus. Its seed too is distinctive, agreeing in shape and the colliculate testa with that of its closest ally *L. montana* Schltr. ex Barker, the only two species known to have the latter character.

Type Material: CAPE PROVINCE—3420 (Bredasdorp); (-CA), Bredasdorpberge, in white sand among TMS boulders, 21/11/1970, W. F. Barker 10812 (NBG, holo., iso.).

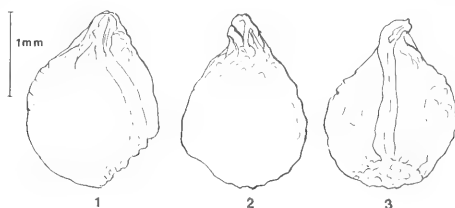


FIG. 18

Lachenalia sargeantii: 1. seed side view; 2. seed from above; 3. seed from below.

This unique species has only been collected in one locality and was found quite by accident by a young visitor from New Zealand, Robert Scott, who when on a hitch-hiking tour of the Western Cape, decided to climb one of the mountains near Bredasdorp in November, 1970, not long after a fire had burnt out a large part of the area. He gathered some small portions of various plants and took them to Mr and Mrs P. A. Sargeant, who brought them to the Compton Herbarium to be identified. Among them were a *Gladiolus* sp. and an inflorescence of this *Lachenalia*, which was completely new to science. Mr Sargeant very kindly arranged a visit to the site with Robert as guide, where a collection was made of specimens for the herbarium and some bulbs for cultivation.

They were found growing in white sand, in open spaces among TMS boulders, on a burnt area with a northern aspect, while the *Gladiolus* sp. was in full flower in crevices of large TMS rocks, where it had been protected from the fire. The *Gladiolus* later proved to be one which had been collected many years before, by Dr H. Bolus, in the same locality at the same time of year. The fact that he failed

to collect the *Lachenalia* suggests that the area had not been burnt at the time, and that *L. sargeantii* requires to be stimulated by fire before it will flower. This supposition is strengthened by the fact that the site was visited in two subsequent seasons, only a few scattered flowering plants were seen on the first occasion, and none at all on the second. Up to the present time the cultivated bulbs have produced leaves but have not flowered.

The species is named in honour of Mr and Mrs Sargeant, who are keen mountaineers and conservationists, and have photographed the high altitude flora of the Western Cape for many years.

SPECIMENS EXAMINED

CAPE PROVINCE—3420 (Bredasdorp): (-CA), 17/10/1970, *R. Scott s.n.* sub. NBG 93894 (NBG), 21/10/1970, *W. F. Barker 10802* (NBG, holo., iso.).

Lachenalia montana Schltr. ex Barker, sp. nov.

Distinguitur foliis 2 linearibus lanceolatis conduplicatis patentibus, inflorescentia racemosa, pedunculo atro-marronino, pedicellis brevis patulis magenteis, floribus cremeis campanulatis ad basim rotundatis, segmentibus externis virido-fuscis gibbosis, segmentis internis externa paulo superantibus apice maculo virido-fusca, staminibus paulo exsertis. seminibus globosis, arillo membranoso undulato decurrente, testa colliculata.

Plant 100–330 mm high. *Bulb* globose 10–20 mm diam., with dark brown leathery tunics produced into a short neck. *Leaves* 2, linear or linear-lanceolate, conduplicate loosely clasping the base of the peduncle, suberect to spreading, 150–350 mm long and up to 20 mm broad at ground level, green tinged with maroon toward apex, without markings. *Peduncle* 80–230 mm high, much longer than the raceme, slender, dark maroon, glaucous or faintly blotched. *Inflorescence* racemose 10 to many-flowered; flowers cernuous, concentrated into a short or long head, sterile portion very short; bracts white or tinged with pale magenta, lanceolate, short up to 2 mm long; pedicels very pale magenta, variable in length 2–15 mm long; in the short-headed fewer flowered inflorescences the pedicel are usually 5 mm long, increasing markedly in length toward the apex, in the more elongated heads the pedicels are short at the base and lengthen very gradually to the apex. *Flowers* 5–9 mm long 4–5 mm diam. at the base, cernuous, campanulate, rounded at the base; tube 2 mm long, outer segments up to 5 mm long, ovate cream with greenish-brown gibbosities; inner segments slightly longer than the outer, up to 7 mm long, 4 mm broad, obovate, cream with a greenish-brown blotch near the apex, upper edge of margin slightly recurved; buds tinged with magenta; stamens a little exserted; ovary obovoid, green, 3 mm diam.; style up to 6 mm long, finally exserted. *Capsule* obovoid, membranous, 4 mm diam; seed globose, aril membranous, undulate, decurrent, testa colliculate.



FIG. 19 a, b.
Lachenalia montana: a. habitat; b. inflorescence.

DIAGNOSTIC CHARACTERS

Lachenalia montana has a number of affinities with *L. sargeantii*, the two narrow conduplicate leaves loosely clasping the peduncle, the unusual capitate type of inflorescence, with the pedicels lengthening toward the apex, and the seed which is similar in shape and has a colliculate testa. However it differs in having very much smaller campanulate flowers, forming a denser head, on much shorter pedicels, and the set of the flowers is cernuous rather than pendulous.



FIG. 20.

Lachenalia montana: 1. seed side view; 2. seed from above; 3. seed from below.

Type Material: CAPE PROVINCE—3419 (Caledon): Onrust, Hermanus (-CA), 16/10/1966, *W. F. Barker 10485* (NBG, holo.).

The earliest known collection of this interesting species was made by Zeyher at Houwhoek, and specimens have languished in the incertae in the collections at Kew and at the South African Museum ever since. In November, 1896 Rudolph Schlechter made copious collections at Houwhoek, at an altitude of 600 m, and distributed them to many herbaria under the manuscript name *Lachenalia montana*. Since that time a number of other collections have been made on the seaward side of the mountains at Hangklip, Kleinmond, and Onrust near Hermanus, some only a few feet above sea level, so that the name is not altogether apt, but it seems expedient, as it has been so widely distributed under the name, to retain it.

Many of the recent collections were made on burnt ground, and at Onrust where it grew and flowered in great profusion after a fire in October 1966, it was observed to decrease in flowering capacity in subsequent seasons, as other vegetation recovered and became dominant.

SPECIMENS EXAMINED

CAPE PROVINCE—3319 (Worcester): Louwshoek Peak (-CC), 15/12/1944, *E. Esterhuysen s.n.* sub (BOL).

—3418 (Simonstown): Hangklip (-BD), 6/12/1950, *J. S. Linley s.n.* sub. SAM 61011 (SAM); 6/12/1950, *Werner s.n.* sub. NBG 72391 (NBG).

—3419 (Caledon): Onrust (-AC), 30/10/1962, *Thomas s.n.* sub. NBG 70038 (NBG); Onrust near Hermanus, 16/10/1966, *W. F. Barker 10485* (NBG, holo.);

Fern Kloof Hermanus (-AD), 11/1/1972 (fruiting), *T. T. Barnard* (NBG); Kleinmond, 30/11/1962, *Cloete s.n.* sub. NBG 70035 (NBG); Houwhoek (-BA), December, *Zeyher* 4294 (SAM, K); Houwhoek, 24/9/1896. *R. Schlechter* 9403 (BOL, BM, G, GRA, K, L, PRE, S, Z).

ACKNOWLEDGEMENTS

In the preparation of this paper I am indebted particularly to Professor E. A. Schelpe who has made the facilities at the Bolus Herbarium available to me since my retirement in 1972, and for his advice and assistance in many other ways, including the preparation of the Latin translations. My sincere thanks also to Professor R. H. Compton for his assistance with the Latin descriptions of the seeds. Dr J. P. Rourke has been most helpful in making my research material in the Compton Herbarium available to me, and in his advice on matters concerned with publication. Mrs. C. Labuschagne kindly prepared the Afrikaans abstract.

I wish to express my thanks to all curators of the herbaria mentioned, who have provided me with facilities or sent specimens on loan, to the Photographic Department of the Jagger Library for the photographs of the paintings, and to the British Museum (Nat. Hist.) and the Bolus Herbarium for the use of the photographs of their herbarium sheets. My grateful thanks to all collectors particularly Miss E. Esterhuysen, Mrs M. Thomas, Mr F. Stayner and Mr and Mrs P. A. Sargeant.

THE IDENTITY OF *POLYPODIUM PÖPPIGIANUM* METT. (FILICES)

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ABSTRACT

The name *Polypodium pöppigianum* Mett. is considered applicable to a small grammitid fern from Victoria Peak, Cape Province, *Grammitis poeppigiana* (Mett.) Schelpe comb. nov. is proposed. In the absence of the type, *Esterhuysen 29290* is proposed as a neotype.

UITTREKSEL

DIE IDENTITEIT VAN *POLYPODIUM PÖPPIGIANUM* METT. (FILICES)

Die naam *Polypodium pöppigianum* Mett. word as toepaslik vir 'n klein grammitiede varing vanaf Victoriapiëk, Kaapprovinsie beskou. *Grammitis poeppigiana* (Mett.) Schelpe comb. nov. word voorgestel. Omdat 'n tipe ontbreek word *Esterhuysen 29290* as neotipe voorgestel.

In 1875, Mettenius, in his treatment of the genus *Polypodium*, as then construed, described a *Polypodium pöppigianum* as follows:

"Rhizoma adscendens, caespitosum, paleis lanceolatis, acuminatis onustum; folia 1-1½'' 'longa, 2¼'' 'lata coriacea, glabra, spathulato-lanceolata, obtusa; nervi immersi, sori ad basin rami antici, breviter oblongi, costae subparalleli, denique costam ipsam tegentes.

Prom.b.spei (in fissuris rupium in fauce umbrosa montium Hott. holland.) Pöppig."

In 1943, Prof. C. L. Wicht of Stellenbosch discovered a small grammitid fern on Victoria Peak and this was referred by Alston & Schelpe (1952) to *Polypodium magellanicum* (Desv.) Copel. It was only realised later that this could represent the "lost" *P. pöppigianum* Mett., but Pöppig was not known to have collected in South Africa. However, the clue was provided in a letter from Pöppig in the Hooker correspondence at Kew, that Pöppig maintained a collector at the Cape. This collector has now been identified as Wilhelm Gueinzus who collected at the Cape between 1839 and 1841. Furthermore, he collected in the Hottentots Holland Mountains, where he discovered *Leucospermum gueinzii* Meisn. and could have ascended Victoria Peak, the highest peak in the vicinity.

Miss E. Esterhuysen, who has re-collected this fern on Victoria Peak, records that it only grows in horizontal crevices on the walls of a south aspect gully in

cliffs at altitudes between 1 450 and 1 500 m. This agrees remarkably well with the habitat description given by Mettenius.

No other grammitid fern has been found in South Africa and little doubt remains that the name *P. pöppigianum* refers to the plant found on Victoria Peak. Unfortunately the holotype is not in Vienna with Pöppig's herbarium, and has not been traced in any other European herbaria. It is presumed lost, or destroyed during World War II.

This south-western Cape fern bears the earliest specific epithet applicable to a widespread Southern Hemisphere fern (Parris, 1975) with an intricate synonymy. Consequently a new combination, *Grammitis poeppigana* (Mett.) Schelpe is proposed (basionym-*Polypodium pöppigianum* Mett., Farngatt., Polypol.: 37, No. 17 (1875)). In the absence of a holotype, *Esterhuysen 29290* (BOL) from Victoria Peak is proposed as a neotype. Isoneotypes have been or will be placed in Kew, Edinburgh and St. Louis.

REFERENCES

- ALSTON, A. H. G. and SCHELPE, E. A. C. L. E., 1925. An annotated check-list of the Pteridophyta of Southern Africa. *Jl S.Afr. Bot.* **18**: 153-176.
- PARRIS, B. S., 1975. A revision of the genus *Grammitis* Sw. (Filicales: Grammitidaceae) in Australia. *J. Linn. Soc. Bot.* **70**: 21-43.

BOOK REVIEW

MESQUITE: ITS BIOLOGY IN TWO DESERT SCRUB ECOSYSTEMS, edited by B. B. Simpson, with pp. 250. New York, Dowden, Hutchinson & Ross, Inc., 1977. \$22.00.

Scientific investigation into the problems concerning our veld takes rather a back seat in South Africa. Veld research often entails long-term projects which are avoided by the average researcher and student.

Is the presence of the mesquite (*Prosopis* spp.) an asset to the arid veld types of South Africa and South West Africa or can it be considered an introduced pest and a danger to the carrying capacity of the veld? It was introduced into Southern Africa many years ago but one hears very little about it in the conference room or in literature.

Mesquite: Its Biology in Two Desert Scrub Ecosystems is a very welcome American contribution to the literature on veld ecology that we in South Africa can also make good use of. The book covers tremendous ground in research by teams of researchers. Topics studied and reported on include: Phenology, morphology and physiology of mesquite; *Prosopis* leaves, flowers and fruits as a resource for insects and invertebrates; Its food, medicinal cosmetic, recreational, fuel and other values; The spread of mesquite; Factors involved in its spread; Control of mesquite. There is also an annotated key to the species of the world of the genus *Prosopis*.

We in South Africa can probably not afford research on as large a scale as the Americans and must therefore make good use of this very comprehensive publication.

The text is adequately supported with illustrations, graphs, maps and photographs. It is a neat, wellbound book comprising 250 pages and measuring 240 × 160 mm. The reader is supplied with a very comprehensive and impressive reference list. The book has an adequate subject index as well as an index of scientific names. It will appeal to the undergraduate and the post-graduate student as well as the research worker.

May this book help to stimulate more interest in our South African veld and ecology and the influence of modern man on its destiny.

J. G. V. JOUBERT



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